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Abstract Due to the rapid advancements of information and communication technologies (ICTs), educational researchers argue that multimodal and new literacies should become common practices in schools. As new ICTs emerge and evolve, students need the new literacies skills and practices to successfully participate fully in the civic life of a global community. Are teachers prepared to integrate ICTs in the classroom to develop students' new literacies skills? The purpose of this study is to suggest a new literacies framework that guides ICTs integration and supports scientific inquiry, as well as investigate middle school teachers' confidence to practice new literacies in science classrooms. The study adopted mixed-methodology design, surveyed 32 middle school science teachers' ICTs and new literacies skills, and randomly observed 15 teachers' new literacies practices in the classrooms. The results revealed that even though teachers have high confidence in using ICTs, the meaningful technology integration and new literacies practices were scarcely observed in their classroom practices.

Keywords New literacies · Scientific inquiry · Middle school · ICTs (information and communication technologies) · Technology integration · Pedagogical practice · Mixed-methodology

H.-Y. Hsu · S.-K. Wang (✉)
School of Education, New York Institute of Technology, Old Westbury, NY, USA
e-mail: skwang@nyit.edu

H.-Y. Hsu
e-mail: hhsu02@nyit.edu

L. Runco
Department of Life Sciences, New York Institute of Technology, Old Westbury, NY, USA
e-mail: lrunco@nyit.edu

Introduction

The dramatic technological revolution, centered on information and communication technologies (ICTs), has posed tremendous challenges that have led teachers to rethink their tenets of deploying technologies in creative and productive ways to enhance teaching and learning. A new technology integration framework should be explored to guide teachers to meet the demands of the contemporary era.

Currently, common approaches of using technologies in the science classroom include the use of (1) equipment to collect data, (2) media to deliver content (concept and procedure), (3) interactive tools, such as simulation or games, to enhance learning, (4) network technology to perform information research, and (5) productivity tools to create reports for findings. Due to the rapid advancements of computer and network technology, the ICTs have evolved now to a point where they can greatly facilitate inquiry learning on many levels, as well as provide new strategies for presenting the nature of science in the classrooms. Hence, new literacies skills are necessary for teachers to apply these ICTs to support their new teaching approaches to improve science learning.

To be fully literate in today's world, students must become proficient in the new literacies of twenty-first century technologies. Multimodal and new literacies should become common practices in schools (Campbell et al. 2010; Coiro et al. 2008; Hsu and Wang 2010). It is expected that teachers have the responsibility to integrate ICTs into the curriculum in order to prepare students for their futures learning, working, and communicating in the twenty-first century. However, the practice of new literacies by students will not occur if teachers are not proficient in ICTs and do not provide meaningful ways to integrate

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ICTs in the learning context. How confident are middle school science teachers to integrate ICTs within their curricula to develop students' new literacies skills? What are teachers' new literacies practices in the classrooms? This paper aims to posit the new literacies framework within the context of science learning, align new literacies components with scientific inquiry skills, and investigate middle school science teachers' confidence to practice new literacies and their pedagogical practices of new literacies in classrooms.

Theoretical Framework

New Literacies Definition and Components

The traditional definition of literacy refers to the ability to read, write, comprehend, and communicate through languages. With the advancement of computer and networking technologies, the definition of literacy has evolved to include the ability to use digital technologies to "identify questions, locate information, evaluate the information, synthesize information to answer questions, and communicate the answers to others" (Leu et al. 2004, p. 1572). This expanded broader set of skills and knowledge to use digital tools to research, comprehend, produce, and communicate are often referred to as "new literacies" (Leu et al. 2004). Some use the terms "digital literacy" (Eshet-Alkalai 2004; Aviram and Eshet-Alkalai 2006) or "ICT literacy" (ETS 2003); however, the emphasis is on the technology operational skills. We adopted the term "new literacies" as it implies the fluency in literacy skills precedent to master technology tools. ICT literacy or digital literacy is commonly considered as technology or information proficiency. New literacies are situated. It differs according to the subject content and refers to technology integration skills in subject areas.

The tools used to support the development of new literacies are called information and communication technologies (ICTs). ICTs refer to hardware and software (applications) that facilitate users to access, retrieve, process, and exchange information. They provide powerful capacities that allow teachers and students to retrieve information beyond textbooks, form social networking groups, facilitate collaboration and communication with people at distant locations, and reach out to the worldly audience outside of the classrooms. These tools require individuals to adapt to new social practices, strategies, skills, and dispositions for their effective uses; thus, there is a need for both teachers and students to cultivate the skill set of new literacies.

Information and communication technologies have become increasingly popular because of the rapid growth and prevalence of network communication technology. The emergence of cost-effective cloud computing concept also accelerates the adoption of ICTs. ICTs have become evidently important in our daily life and education, which is particularly true for our young generation—they are highly motivated when they have ICT-based experience in the classrooms (McFarlane and Sakellariou 2002). Popular ICTs are used within educational and social contexts in many ways. For instance, document-editing tools, such as Google Docs and Microsoft Office Live, allow users to collaboratively create and share their documents, spreadsheets, and presentations online, as well as access and manage their work from any location. Social networking tools, such as Facebook, Google Plus, Edmodo, and Slideshare, allow users to communicate and share multimedia elements online. Multimedia editing tools, such as Picasa web album and iMovie, provide users free online image editing and sharing services. Google Earth provides a virtual globe, maps, and a variety of geographical information. All of these ICTs can be adopted by teachers to develop students' new literacies skills through the multimodal formats of information that takes on dynamically interactive elements. Most ICTs are free and easily accessible. They make information more accessible, thinking more visible, exchange of ideas more frequent and immediate, and lifelong learning autonomic (Linn 2004). ICTs also change the frame of mind in using technology. The new paradigm indicates the profound shift noted from using technology as "learning from" tools to "learning with" cognitive tools. Cognitive tools refer to "technologies that enhance the cognitive powers of human beings during thinking, problem solving, and learning (Jonassen and Reeves 1996, p. 693)." Rather than having students learning from the technology as passive information consumers, they take on the responsibility of producing information through multimodal channels.

Even though teachers are encouraged to integrate ICTs, the current teachers' use of technology is usually limited to support their personal communication and classroom materials preparation. Teachers' use of ICTs can be categorized into the following: locating and preparing instructional materials, presenting information, communication and collaboration, and administrative work (Bebell et al. 2004; NCES 2000). Teachers' limited use of ICTs is understandable because these technologies are designed to facilitate information retrieval and communication. The question is: Since teachers frequently use ICTs to enhance their productivity, do they encourage students to use ICTs as well to facilitate cognitive skills? Unfortunately, the student-centered ICT integration is scarce in the literature. Tamim et al. (2011) conducted a meta-analysis study to investigate the impact of technology on learning. They examined 25 studies, published after 1985, that met the rigorous research design and technology integration criteria. Among these studies, 20 used CAI (computer-assisted instruction) as learning aids, one used simulation tool, and only four used ICTs as cognitive tools. Technology is being treated as a digital version of learning resources; it is still far away from being integrated as a cognitive tool to practice a constructivist approach of learning.

Today, our students are considered "digital natives" (Prenksy 2001) and use digital technology in their daily life for social functioning. They are technology savvy and are more motivated and engaged in learning if technology is integrated in the classroom instruction. Nevertheless, using technology alone does not lend itself to better learning outcomes. Educators should facilitate students to use technology in meaningful ways to support the development of their cognitive skills and content learning. Hsu and Wang (2010) argued that a student fluent in new literacies should demonstrate proficiency in three important areas: technology skills (the ability to operate computer and network technologies), literacy skills (read, write, comprehend, and communicate), and cognitive skills (critical thinking, problem solving, and research and evaluation skills). Figure 1 demonstrates the components of new literacies fluency. In order to be "literate" in new literacies, students need to have fluent technology operational skills to use ICTs, be equip with fluent literacy skills to understand and communicate the content, and have proficient cognitive skills to process information. These three underlying foundational components are crucial to support the practice of new literacies in the science context. This flowchart serves as a theoretical framework for using ICTs as a cognitive tool to support scientific inquiry.

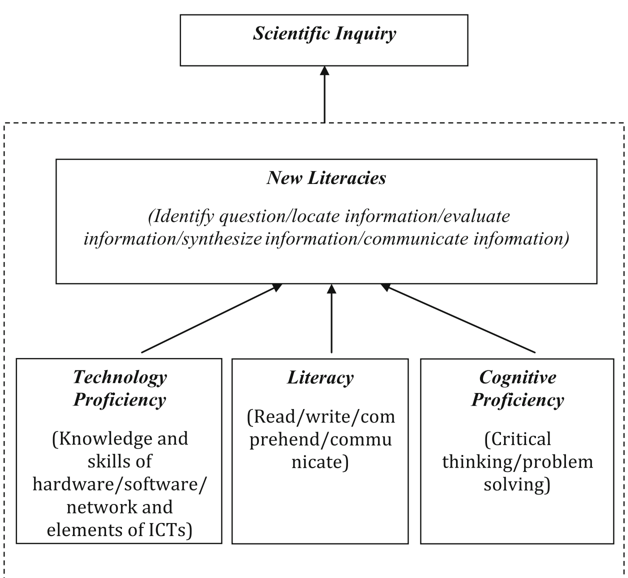

Fig. 1 The new literacies elements

The development of new literacies lies in the sufficient training in ICTs skills, cognitive skills, and literacy skills. Cultivating new literacies cannot be deemed as the information technology teachers' responsibility; rather, it should occur in all content areas to directly or indirectly affect the growth of the three components of new literacies. To be fully literate and fluent in new literacies, our students need to be given the opportunity to practice their technology skills, as well as their literacy and cognitive skills, guided by the sophisticated curricular knowledge of their teachers. To ensure students' preparedness to the changed nature of literacy practices at school and in their everyday lives, new literacies need to be explicitly taught across the curriculum. Content-specific learning is then constructed within "situated" new literacies.

Cultivate Students' New Literacies Skills to Support Scientific Inquiry

Our focus in this paper is to lay the theoretical groundwork to help us explore new literacies through the practice of pedagogical activities in different subject areas (Kaper 2000). In this study, we specifically investigate new literacies situated in the context of science learning. According to the National Science Education Standards (NRC 1996), scientific literacy is the desired outcome of science education and "inquiry is central to science learning." To engage in inquiry, students need to be able to use scientific knowledge to identify questions and to draw evidence-based conclusions to understand and help make decisions about the natural world and the changes made to it through human activity.

In addition, the National Science Teachers Association Position Statement (NSTA Board of Directors 2004) recommends teachers prepare students' abilities to do scientific inquiry by facilitating students to (1) ask questions that can be answered through scientific investigations, (2) collect evidence needed to answer a variety of questions, (3) interpret and analyze data through appropriate tools, (4) draw conclusions to create explanations based on evidence, and (5) communicate and defend results to their peers and others. When teachers engage students in the scientific inquiry process, students can actively develop their understanding of science (Chang and Mao 1999; Ertepinar and Geban 1996; Hakkarainen 2003), the nature of science (Schwartz et al. 2004), and their motivation and attitudes toward learning science (Cavallo and Laubach 2001; Chang and Mao 1999; Minner et al. 2010; Paris et al. 1998).

When we closely examine the components of scientific literacy and new literacies, they are interdependent and complementary. The following list explains how new literacies support each of the scientific inquiry principles (Table 1).

Table 1 New literacies supporting science inquiry

New literacies components	Principles of scientific inquiry				
	Engaged by questions	Give priority to evidence	Formulate explanations	Evaluate explanation and generate alternative explanations	Communicate and justify the explanations
Identify important questions	*X*				
Locate information	*X*	*X*	*X*	*X*	
Evaluate information		*X*	*X*	*X*	X
Synthesize information			*X*	*X*	X
Communicate answers					X

X indicates how new literacies support scientific literacy

- Identify important questions: Students use research tools to identify scientifically testable questions from text-based or multimedia-based resources.
- Locate information: Students locate and organize multimedia formats of information and evidence relevant to the question, such as numerical data, texts, video clips, and images.
- Evaluate usefulness of information: Students identify and interpret credible information and evidence to answer questions.
- Synthesize information: Students use productivity tools to create information to present their research findings using multimodal texts, including charts, images, video, or interactive content.
- Communicate answers: Students use ICTs and social networking tools to facilitate team collaboration, and share their research results with their audience.

Here, we present an ideal example of how teachers can adopt ICTs to facilitate students' new literacies and scientific inquiry skills: When teaching the unit of human impact on the living environment, the teacher first provides the class with background information of the content. Next, the teacher facilitates the students to use search engines (e.g., http://news.google.com) to look for articles regarding water quality issues and studies in their neighborhood, and have them share their articles with their classmates using a social networking site, such as Edmodo (http://www.edmodo.com). The article research helps students apply what they learn in class to real-life experiences, as well as what scientific questions professional scientists are asking today regarding water quality, such as human impact on water quality. The teacher then provides reliable cyber databases, such as U.S. Geological Survey (USGS), MYSOUND (Monitoring Your Sound), NOAA (National Oceanic and Atmospheric Administration), or Google Public Data Explorer, allowing students to collect public data. With the teacher's guidance, students generate scientific testable questions and hypotheses that can be answered using the data the student collected from the databases. Students also discuss their questions/hypotheses with peers using Edmodo. Sample questions can be: Is the pH level of the water at Location A affected by the surrounding population density? Is the pH level of the water at Location A related to its annual precipitation? Next, students use a spreadsheet to log and organize their data and create charts to find correlations among factors. Using this information collectively, the student can examine their hypotheses and formulate explanations. If a student does not accept their hypothesis, they will need to research other alternative explanations. Images, videos, and hyperlinks can be a part of their report. Credible information should be cited in the report. Finally, students present their research using Edmodo and share their findings and conclusions with peer classmates. In this example, students need to have technology skills to operate ICTs, cognitive skills to solve problems, and literacy skills to comprehend the subject content. When students experience this scientific inquiry process, they are in fact simultaneously practicing new literacies. For teachers to design this type of student-centered learning environment, they need to possess strong ICT skills, scientific inquiry skills, and solid knowledge of implementing various ICTs to support the process of inquiry.

Our Translation of New Literacies

The definition and practices of new literacies vary in different fields, resulting in literacy-oriented studies and ICTs-oriented studies. Leu and his colleagues are the earliest group to investigate new literacies of ICTs, and the majority of their work focuses on reading comprehension through the use of ICTs (Castek et al. 2007; Coiro 2003; Coiro et al. 2007; Karchmer et al. 2005). Now, many others follow a similar research strand to study ICTs' influence on students' literacy practices (Hsu and Wang 2011; Sweeny 2010; Trusaw and Olson 2010; Wolsey and Grisham 2007). These studies collectively suggest that students need a broader set of literacy skills to effectively comprehend and utilize multimodal information, and teachers play a critical role in the process of developing these skills. Previous results also encouraged the research of new literacies integration into context-specific subject areas.

Previous ICTs-oriented studies on teachers are less subject specific, and tend to focus on teachers' ICTs skills mastery and self-efficacy (Demiralay and Karadeniz 2010; Markauskaite 2007), as well as attitudes and perception of adoption (Regan 2010; Wikan and Molster 2011; Tezci 2011). More studies are needed to examine teachers' technology integration strategies in various subject areas as opposed to technology operational skills on specific tools.

To guide the research with a meaningful ICTs integration framework that is student centered, we proposed the components of new literacies to include technology skills, cognitive skills, and literacy skills, and argued the importance of applying new literacies within the scientific inquiry process. Literature suggests that teachers' professional practices are influenced by their beliefs (Crawley 1990; Czerniak 1996), thus directly affect the educational reforms, including inquiry approach and technology integration (Bryan and Atwater 2002; Higgins and Spitulnik 2008; Songer et al. 2002). ICT skills are the foundational set of skills required for teachers to practice new literacies. Teachers who demonstrate a high level of ICT adoption share similar characteristics: positive attitude toward ICTs' educational benefits, strong confidence in ICT skills, and rich access to resources (Drent and Meelissen 2008; Mumtaz 2000; Rakes et al. 2006). It is critical for teachers to create a learning environment that fosters students' scientific inquiry and cultivates their digital literacy, because their confidence, motivation, and attitude in using technology greatly influence their teaching practices (Bitner and Bitner 2002; Cox and Webb 2004; Mueller et al. 2008). Therefore, it is necessary to understand teachers' confidence in ICTs skills in order to understand their new literacies practices in the classroom.

In this study, we investigated middle school teachers' new literacies skills in the science classrooms. In order to learn teachers' new literacies skills, we need to know their mastery of ICTs skills and confidence in new literacies skills in the context of science learning. There are some studies that investigated the pedagogical use of ICTs in science instruction, which shed light on how science teachers used new literacies to support students' inquiry (Donnelly et al. 2011; Hennessy et al. 2007). In addition to these studies, we investigated the teachers' new literacies practices in science classrooms to see if their new literacies practices relate to their confidence in new literacies skills. Our research was guided by the following three research questions:

1. What are the middle school science teachers' confidence levels in ICT skills?
2. What are the middle school science teachers' confidence levels in new literacies?
3. Do middle school science teachers' classroom practices reflect their confidence in ICT skills and new literacies?

Methods

Research Design

Our research study adopted the mixed-methodology design (Tashakkori and Teddlie 2006) to collect and analyze both quantitative (surveys) and qualitative (classroom observations and interviews with external evaluators) data. Thirty-two middle school science teachers teaching Living Environment in the New York City School District volunteered to participate in this study. Among the participants, five were males and twenty-seven were females. Their teaching experiences ranged from 1 to 21 years, with an average of 8.2 years. Participants spent approximately 30 min filling out three surveys. Fifteen teachers were randomly selected for classroom observation for one class session.

Data Collection and Analysis

Survey Instruments

To measure teachers' ICT skills, we adopted the ICT literacy survey developed by Markauskaite (2007), as it measures both teachers' technical and cognitive capabilities. The survey includes 35 items and measures pre-service teachers' confidence in the following five components of ICTs and cognitive skills: problem solving, communication and metacognition, basic ICT capabilities, analysis and production with ICTs, and information and internet-related skills. The survey was developed based on pre-service teachers' data; therefore, we made minor modifications to ensure the language was appropriate for in-service teachers. The Cronbach's alpha coefficient in the original paper of the five constructs is reported as .90, .82, .91, .92, and .92, respectively, while the Cronbach's alpha coefficient in this study is .89, .75, .86, .85, and .92. All items showed α levels above the 0.70 threshold recommended by Nunnally (1967; Nunnally and Bernstein 1994).

There is not a single ideal instrument that would specifically meet the needs of the study to measure teachers' confidence in new literacies. This is, in part, because our definition of new literacies is inclined to use different ways to utilize ICTs as cognitive tools to decode and encode meanings of context-specific subject matters and is situated in science learning in this project. Therefore, an instrument that can assess the teachers' confidence in applying ICTs and cognitive skills in a scientific context is needed for the purpose of the study. We developed a 33-item instrument (New Literacies Scenarios) and conducted a pilot study to determine item correlation and reliability. The instrument consisted of three scenarios situated in middle school living environment learning standards, and each scenario is followed by several items listing the procedure and new literacies skills needed throughout the scientific inquiry process. The final instrument consisted of 31 items using a Likert scale ranging from (1) "I am not familiar with how to do it," to (5) "I am very familiar with how to do it and can teach others to do it."

Sample scenario You are attending a professional development workshop. You are assigned into a group of 4 teachers who together will work with another 4 teachers from another state across the country to conduct a group project. Your project goal is to investigate unique plants in your neighborhood, and then compare the plants in your neighborhood to the plants from where the teachers are located across the country. The group must articulate differences and similarities found and a rationale for these differences, and then present the findings. You are elected as the group leader. You are given the name and emails of the 7 other teachers in your group. Using technology, how would you establish and maintain the group's communication to successfully complete your assignment?

Sample item I can use a spreadsheet to document and organize the plant species and locations our group found in the various locations.

Each item was grouped into one of the five new literacies components (*identify questions, locate information, evaluate information, synthesize information, and communicate information*). Cronbach's alpha was used to measure the internal consistency of the items of each component. All items showed α levels above the 0.70 threshold recommended by Nunnally (1967; Nunnally and Bernstein 1994): identify questions 0.827, locate information 0.800, evaluate information 0.700, synthesize information 0.802, and communicate information 0.88. The Pearson correlation among categorized new literacies components was significant ($p < .001$).

Classroom Observation Checklist

We developed a "Technology Observation Checklist" to help us learn teachers' new literacies practices in the classrooms. The checklist indicated the classroom technology available for teachers and students, classroom organization, teacher's role, ICTs adopted in this class session, ICTs-related activities conducted in this session, and how each activity aligned with new literacies components. ICTs include the following tools: word processing, spreadsheet, presentation, drawing, map, Google Earth, web search engines, social networking tools, blog, YouTube, 3D simulation environment, web editing, movie production, and instant messenger. There is also an "additional comments" section on the form for observers to document notable events that may have occurred in the classrooms.

In order to ensure that the New Literacies Scenarios and the Technology Observation Checklist are valid to the research purpose, a panel of four reviewers with backgrounds in science education, new literacies, and educational technology was asked to review the literature and generate the essential constructs and items aligned with middle school science learning standards, the new literacies components, and the common adopted ICTs. Each item suggested by all panel members was rated and selected according to the final rating scores.

Interview with the Observers

The classroom observations were conducted by two evaluators who had years of science observation experience. They were only involved in the observations, not in any part of the research process. The inter-rater reliability was calculated to ensure their observation scorings were similar. There was an excellent inter-rater reliability (=0.9, $p < .01$). The researchers interviewed with the two observers after all observations were completed. During the interview, the observers thoroughly described the classroom practices they observed. The interview questions were centered on teachers' access to technology, students' use of technology, students' learning motivation, teachers' technology integration strategies, and students' new literacies practices, mainly to triangulate the observation data.

Results

A Shapiro–Wilk Tests of Normality ($n < 50$) was used to ascertain the normal distributions of responses for both ICT literacy and new literacies scenarios surveys. The responses were normally distributed for both surveys.

ICTs and Cognitive Capabilities

The descriptive statistics of the ICT literacy survey answered the first research question: What are the middle school science teachers' confidence levels in ICT skills?

The results in Table 2 showed that participant teachers were most confident with their basic ICT capabilities (e.g., operating a computer, managing files, word processing), followed by communication and metacognition (e.g., collaboration, judge, reflect), problem solving (e.g., plan, find, manage, evaluate), information and internet-related

Table 2 ICT skills means and standard deviation

	Component	No. of items	*M*	SD	Ranking
Technology skills	Basic ICT capabilities	6	4.51	.495	1
Cognitive skills	Communication and metacognition	3	4.32	.550	2
Cognitive skills	Problem solving	6	4.11	.621	3
Technology skills	Information and internet-related skills	9	3.53	.879	4
Technology skills	Analysis and production with ICT	7	3.35	.693	5

$N = 32$ (1 = strongly disagree, 5 = strongly agree)

capabilities (e.g., navigation, create web pages, images, and graphics), and least confident with their analysis and production capabilities (e.g., spreadsheets, databases).

Teachers had stronger confidence with their basic ICT capabilities (mean = 4.51) than their analysis and production capabilities using ICTs (mean = 3.35, $t = 12.758$, $p = .000$), which was consistent with the findings generated from Markauskaite's study (2007). In terms of cognitive skills, they had stronger confidence with their communication and metacognition skills (mean = 4.32) than problem solving skills (mean = 4.08, $t = -2.87$, $p = .008$) and information/internet-related capabilities (mean = 3.62, $t = 3.69$, $p = .001$), and stronger problem solving skills than information/internet-related capabilities ($t = 3.42$, $p = .002$). These findings were also consistent with Markauskaite's study.

We did not find significant differences among these constructs when using participant teachers' age, gender, and teaching experiences to test the mean differences. Even though teachers' responses showed variances between groups, the differences were not significant.

Overall, these findings suggest that teachers had strong confidence in their basic computer operational skills and cognitive skills, but their confidence in advanced ICTs and networking technology was relatively low. These technologies, such as database, movie production, spreadsheet, and web editing tools, are often perceived as cognitive tools (Jonassen and Strobel 2006; Reeves 1998). Lacking sufficient skills in these technologies can hinder teachers' abilities to use technology as cognitive tools, even if they have strong cognitive skills.

Teachers' Confidence in New Literacies Skills

Descriptive statistics answered the second research question: What are the middle school science teachers' confidence levels in new literacies?

Table 3 shows that participant teachers are more familiar with using ICTs to locate information (multimedia formats of information), followed by using ICTs to evaluate information (to determine the usefulness of the data and use it accurately within the context), using ICTs to communicate information (to use web 2.0 tools to communicate and collaborate), using ICTs to synthesize information (to create multimedia formats of information), and least familiar with using ICTs to identify questions (to create plans to use ICTs to conduct scientific inquiry). Teachers' confidence levels in their research skills and ability to evaluate information are high. This finding reflects the teachers' tendency and frequency of using ICTs to search for information, resulting in higher confidence level in these areas. The ability to synthesize information is low because it requires the teachers' proficiency skills to handle multimodal formats of information. The ability to generate a plan using ICTs to conduct research is the lowest. The explanation could be that the teachers believed that it is difficult to generate a solid research plan using ICTs, probably because teachers themselves have not been well trained to develop scientifically testable questions or a research plan. This suggestion is supported by previous findings regarding science teachers' lack of training in inquiry-based instruction (Davis et al. 2006; Harlen 1997; Trumper 2003).

Table 3 New literacies scenarios instrument means and standard deviations

Component	No. of items	*M*	SD	Ranking
Locate information	5	3.62	.858	1
Evaluate information	6	3.47	.620	2
Communicate information	7	3.25	1.00	3
Synthesize information	7	3.10	.795	4
Identify questions	6	3.04	.857	5

$N = 32$ (1 = I am not familiar with how to do it, 5 = I am very familiar with how to do it and can teach others to do it)

A paired sample t test revealed that the following comparisons between constructs were significantly different: locate information stronger than identify questions ($t = 5.71$, $p = .000$); evaluate information stronger than identify question ($t = 3.63$, $p = .001$); locate information stronger than evaluate information ($t = 2.8$, $p = .01$); locate information stronger than synthesize information ($t = 5.87$, $p = .00$); locate information stronger than

Table 4 Correlation between ICT skills and new literacies skills

	Problem solving	Communication and metacognition	Basic ICT capabilities	Analysis and production	Information and internet-related capabilities
Identify questions	.299	.053	.368*	.375*	.587**
Locate information	.230	.057	.475**	.339	.713**
Evaluate information	.392*	.085	.369	.477*	.543**
Synthesize information	.301	.056	.329	.365*	.606**
Communicate information	.176	−.180	.456**	.437*	.741**

* $p < .05$; ** $p < .01$

Table 5 Frequency of students' technology use in the observed classrooms ($N = 15$)

	Never happened	Occurred once or twice	Major activity	New literacies components alignment
Word processing tools	14	1	0	4, 5
Spreadsheet tools	15	0	0	–
Presentation tools	13	2	0	5
Drawing tools	15	0	0	–
Map tools	14	1	0	2
Google Earth	15	0	0	–
Web search engines	13	1	1	2, 3
Social networking tools	15	0	0	–
Blog	15	0	0	–
YouTube or video streaming tools	15	0	0	–
Second Life/OpenSim	15	0	0	–
Web editing tools	15	0	0	–
Movie production tools	15	0	0	–
Instant messengers	15	0	0	–

New literacies components: 1, identify question; 2, locate information; 3, evaluate information; 4, synthesize information; 5, communicate information

communicate information ($t = 3.83$, $p = .001$); evaluate information stronger than synthesize information ($t = 2.55$, $p = .017$). There was no significant difference found among new literacies constructs using participant teachers' age, gender, and teaching experiences to test the mean differences.

The Pearson correlation showed the correlation among ICT literacies and the new literacies constructs (Table 4). The results suggest that advanced ICTs skills did contribute to higher new literacies skills, which supported our argument that teachers need to master the skills of using ICTs to be able to facilitate the cognitive tools approach and practice new literacies.

Teachers' New Literacies Practices in the Classrooms

The Technology Observation Checklist provided information about the teachers' actual classroom practices to answer the third research question: Do middle school science teachers' classroom practices reflect their confidence in ICT skills and new literacies?

The observation revealed that the fifteen middle school science teachers observed in our study had limited access to technology. Students in eight of the classrooms did not have any access to computers. In five of the classrooms, students had access to less than 10 computers. One classroom had 12 computers and one had 27 laptops, allowing access for each student. In addition, seven classrooms were equipped with a Smartboard connected to a teacher's station. A teacher-led lecture occurred in eight classrooms, while a small group discussion occurred in the remaining seven classrooms. One item required evaluators to document students' motivation and engagement (number of students who seemed to be engaged in learning tasks). The results showed that the observed students' motivational levels did not correlate with the teachers' role (e.g., lecture, facilitate discussion, facilitate group work).

Table 5 shows the frequency of technology use by students during the observed session. The results revealed poor technology integration in these classrooms. Students in one class had the opportunity to use a word processing tool, while two classes used presentation tools, one class used map tools, and one class used web search engines to search for factual information. Among all of the observations, there was only one class in which students were actively engaged in using web search engines to look for topic-related information and pictures—This class was most comparable to a new literacies-saturated classroom.

From the observation data and the interviews with the observers, we concluded that the participant teachers' ICT literacy confidence and new literacies confidence were not reflected in their classroom practices. Many science teachers were accustomed to the lecture-based instruction. The limited access to computers posed a great challenge for the teachers to practice new literacies in their classrooms. In particular, new literacies-related tasks rarely or never occurred in the classrooms in which the teachers had computers for students to utilize. When student-centered technology integration activities occurred, students were highly focused and motivated. The observers' notes also revealed that many teachers' science teaching is driven by the national standardized assessment (state exam). This finding corresponds with a recent national survey of middle and high school science teachers' responses to standardized testing (Aydeniz and Southerland 2012). The study reports that even though 60 % of the surveyed teachers do not believe standardized testing would improve students' science learning, 51 % of these teachers' instruction is geared toward standardized testing. Those who do not reinforce the idea of teaching to the test do support students' development of inquiry skills. Under the pressure of improving students' standardized test scores, it is not surprising that we observed a lack of inquiry-related activities in these classrooms.

Conclusion and Suggestions

This study argues that new literacies fluency lies in the proficiency of technological skills, cognitive skills, and literacy skills. We developed the new literacies scenarios instrument that includes the following five new literacies components: identify a question, locate information, evaluate information, synthesize information, and communicate information. We surveyed 32 middle school science teachers to learn their confidence in ICT literacy and new literacies. It is common for respondents to over- or underestimate their self-efficacy in certain areas and that the survey may not reflect their actual capabilities (Pajares 2002); therefore, we designed a technology checklist to also capture the teachers' actual classroom practices. The results revealed that our participant teachers had high ICT literacy confidence and were moderately familiar with new literacies skills, but rarely practiced new literacies in their classrooms. Teachers have strong confidence in their basic ICT skills and cognitive skills, but had relatively low confidence in their advanced ICT skills. The results echo the study conducted by Judson (2006) that teachers' strong beliefs in technology integration were not necessarily reflected in their classroom practices. In our study, the findings further suggested that teachers need to master advanced ICT skills, which is a strong indicator of their technology integration abilities to facilitate students' cognitive skills. Lacking sufficient skills in these technologies can hinder teachers' abilities to use technology as cognitive tools to facilitate the knowledge construction and representation in the process of scientific inquiry.

The major barrier for new literacies practice to occur in our study was the limited access to technology. Many teachers had to reserve laboratories in order to facilitate student-centered activities using ICTs. New literacies-saturated classrooms require an enrichment of ICTs resources. Without sufficient technology support, students lose the opportunity to practice new literacies skills in the classrooms and apply their already savvy technology skills to school work.

Increasing teacher and student access to technology is just the first step toward the ideal learning environment to develop new literacies to support scientific inquiry. Schools and science teacher education programs should provide professional development opportunities to enhance teachers' ICTs integration skills that support scientific inquiry, as opposed to decontextualized technology skills training. The professional development should include (1) solid training on scientific inquiry, (2) advanced ICTs skills, especially productivity tools to produce multimodal texts, (3) new literacies components and their alignment with scientific inquiry, and (4) strategies to facilitate students to use ICTs to conduct scientific inquiry. From this study, we learned that the majority of teachers have high confidence in their ICT skills. Therefore, the teachers are in need of strategies to apply their ICT skills to support science teaching and students' learning. The design of professional development should focus on providing effective training to connect teachers' strong ICTs skills to their classroom practices.

The alignment of new literacies and science literacy demand from us a vision that includes the integration of new literacies within a science inquiry process. These new literacies practices include technology skills, cognitive skills, and literacy skills in a science learning context. To ensure such integration occurs, we need to make sure all teachers are ready to teach with technology as cognitive tools, and they need to participate in technology-based planning and teaching to meet their students' academic needs in the situated science inquiry process. To help teachers practice new literacies, curriculum and teacher professional development should embed new literacies components so teachers can use ICTs skillfully to practice new literacies that support scientific inquiry. Only through meaningful technology integration will teachers see the value and switch their paradigm from “learning from” to “learning with” technology. If teachers switch their technology integration paradigm, students would have a chance to practice new literacies and develop their scientific inquiry skills using ICTs. That is, students should be able to use ICTs to find useful information to help them form and refine scientifically testable questions that are relevant to their life or their interests. Students should be able to establish a hypothesis, collect valid data, analyze data, present data in multimodal formats, examine the hypothesis, reshape the next research questions, and communicate their findings with the community.

For future research in this area, we suggest that more classroom observation sessions should be conducted in order to fairly capture teachers’ classroom practices, especially for the purpose of evaluating longitudinal data. More demographic and background data could also be collected to explore the factors influencing teachers’ new literacies skills and practices. Another future avenue of research is to study the impact of teachers’ new literacies practices on students’ science learning motivation and science learning outcomes. Lastly, comparisons between teachers’ and students’ new literacies could also help reveal the gap between teachers’ and students’ new literacies skills.

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References

Aviram A, Eshet-Alkalai Y (2006) Towards a theory of digital literacy: three scenarios for the next steps. Eur J Open Distance E-Learn 1. Retrieved from http://www.eurodl.org/?p=archives&year=2006&halfyear=1&article=223

Aydeniz M, Southerland SA (2012) A national survey of middle and high school science teachers’ responses to standardized testing: is science being devalued in schools? J Sci Teach Educ 23(3):233–257

Bebell D, Russell M, O’Dwyer L (2004) Measuring teachers’ technology uses: why multiple-measures are more revealing. J Res Technol Educ 37(1):45–63

Bitner N, Bitner J (2002) Integrating technology into the classroom: eight keys to success. J Technol Teach Educ 10(1):95–100

Bryan LA, Atwater MM (2002) Teacher beliefs and cultural models: a challenge for science teacher preparation programs. Sci Educ 86(6):821–839

Campbell T, Wang S-K, Hsu H-Y, Duffy AM, Wolf PG (2010) Learning with web tools, simulations, and other technologies in science classrooms. J Sci Educ Technol 19(5):505–511

Castek J, Leu DJ Jr, Coiro J, Gort M, Henry LA, Lima C (2007) Developing new literacies among multilingual learners in the elementary grades. In: Parker L (ed) Technology-mediated learning environments for young English learners: connections In and out of school. Lawrence Erlbaum Associates, Mahwah, pp 111–153

Cavallo A, Laubach T (2001) Students’ science perceptions and enrollment decisions in differing learning cycle classrooms. J Res Sci Teach 38(9):1029–1062

Chang C, Mao S (1999) Comparison of Taiwan science students’ outcomes with inquiry-group versus traditional instruction. J Educ Res 92(6):340–346

Coiro J (2003) Reading comprehension on the Internet: expanding our understanding of reading comprehension to encompass new literacies. Read Teach 56:458–464

Coiro J, Dobler B, Coiro J, Dobler E (2007) Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. Read Res Q 42:214–257

Coiro J, Knobel M, Lankshear C, Leu DJ (2008) Central issues in new literacies and new literacies research. In: Coiro J, Knobel M, Lankshear C, Leu DJ (eds) Handbook of research on new literacies. Lawrence Erlbaum Associates, Taylor & Francis Group, New York, pp 1–21

Cox MJ, Webb ME (2004) ICT and pedagogy: a review of the research literature. British Educational Communications and Technology Agency/Department for Education and Skills, Coventry/London

Crawley FE (1990) Intentions of science teachers to use investigate teaching methods: a test of the theory of planned behavior. J Res Sci Teach 27:685–697

Czerniak CM (1996) Relationship between teacher beliefs and science education reform. J Sci Teach Educ 7(4):247–266

Davis EA, Petish D, Smithey J (2006) Challenges new science teachers face. Rev Educ Res 76(4):607–651

Demiralay R, Karadeniz S (2010) The effect of use of information and communication technologies on elementary student teachers’ perceived information literacy self-efficacy. Educ Sci Theory Pract 10(2):841–851

Donnelly D, McGarr O, O’Reilly J (2011) A framework for teachers’ integration of ICT into their classroom practice. Comput Educ 57:1469–1483. doi:10.1016/j.compedu.2011.02.014

Drent M, Meelissen M (2008) Which factors obstruct or stimulate teacher educators to use ICT innovatively? Comput Educ 51:187–199

Educational Testing Service (2003) Digital transformation: a framework for ICT literacy. Educational Testing Service, Princeton. Retrieved from http://www.ets.org/research/ictliteracy/

Ertepinar H, Geban O (1996) Effect of instruction supplied with the investigative-oriented laboratory approach on achievement in a science course. Educ Res 38(3):333–341

Eshet-Alkalai Y (2004) Digital literacy: a conceptual framework for survival skills in the digital era. J Educ Multimed Hypermed 13(1):93–106

Hakkarainen K (2003) Progressive inquiry in a computer-supported biology class. J Res Sci Teach 40(10):1072–1088

Harlen W (1997) Primary teachers’ understanding in science and its impact in the classroom. Res Sci Educ 27(3):323–337

Hennessy S, Wishart J, Whitelock D, Deaney R, Brawn R, Velle L (2007) Pedagogical approaches for technology-integrated science teaching. Comput Educ 48(1):137–152. doi:10.1016/j.compedu.2006.02.004

Higgins TE, Spitulnik MW (2008) Supporting teachers’ use of technology in science instruction through professional development: a literature review. J Sci Educ Technol 17(5):511–521. doi:10.1007/s10956-008-9118-2

Hsu H-Y, Wang S-K (2010) Using gaming literacies to cultivate new literacies. Simul Gaming 41(3):400–417

Hsu H-Y, Wang S-K (2011) The impact of using blogs on college students' reading comprehension and learning motivation. Lit Res Instr 50(1):68–88

Jonassen DH, Reeves TC (1996) Learning with technology: using computers as cognitive tools. In: Jonassen DH (ed) Handbook of research for educational communications and technology. Macmillan, New York, pp 693–719

Jonassen D, Strobel J (2006) Modeling for meaningful learning. In: Hung D, Khine MS (eds) Engaged learning with emerging technologies. Springer, Dordrecht, pp 1–27

Judson E (2006) How teachers integrate technology and their beliefs about learning: is there a connection? J Technol Teach Educ 14(3):581–597

Kaper LF (2000) New technologies, new literacies: focus discipline research and ESL learning communities. Lang Learn Technol 4(2):105–128

Karchmer RA, Mallette M, Kara-Soteriou J, Leu DJ Jr (eds) (2005) New literacies for new times: innovative models of literacy education using the Internet. International Reading Association, Newark

Leu DJ Jr, Kinzer CK, Coiro J, Cammack D (2004) Toward a theory of new literacies emerging from the Internet and other information and communication technologies. In: Ruddell RB, Unrau N (eds) Theoretical models and processes of reading, 5th edn. International Reading Association, Newark, pp 1568–1611

Linn MC (2004) Using ICT to teach and learn science. In: Holliman R, Scanlon E (eds) Mediating science learning through information and communications technology. Routledge Falmer, London, pp 9–26

Markauskaite L (2007) Exploring the structure of trainee teachers' ICT literacy: the main components of, and relationships between, general cognitive and technical capabilities. Educ Tech Res Dev 55:547–572

McFarlane A, Sakellariou S (2002) The role of ICT in science education. Camb J Educ 32(2):219–232

Minner DD, Levy AJ, Century J (2010) Inquiry-based science instruction: what is it and does it matter? Results from a research synthesis years 1984 to 2002. J Res Sci Teach 47(4):474–496

Mueller J, Wood E, Willoughby T, Ross C, Specht J (2008) Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. Comput Educ 51(4):1523–1537

Mumtaz S (2000) Factors affecting teachers' use of information and communications technology: a review of the literature. J Inf Technol Teach Educ 9(3):319–342

National Center for Education Statistics, U.S. Department of Education (2000) Teachers' tools for the 21st century. A report on teachers' use of technology. Author, Washington, DC. Retrieved from http://nces.ed.gov/surveys/frss/publications/2000102/index.asp

National Research Council (1996) National science education standards. The National Academies Press, Washington, DC

National Science Teacher Associations Board of Directors (2004) NSTA position statement: scientific inquiry. Retrieved from http://www.nsta.org/about/positions/inquiry.aspx

Nunnally JC (1967) Psychometric theory. McGraw Hill, New York

Nunnally JC, Bernstein IH (1994) Psychometric theory, 3rd edn. McGrawHill Series in Psychology, McGraw-Hill, Inc., New York, pp 264–265

Pajares F (2002) Overview of social cognitive theory and of self-efficacy. Retrieved from http://www.emory.edu/EDUCATION/mfp/eff.html

Paris S, Yambor K, Packard B (1998) Hands-on biology: a museum–school–university partnership for enhancing students' interest and learning in science. Elem Sch J 98(3):267–289

Prenksy M (2001) Digital natives, digital immigrants. On the Horizon 9(5). Retrieved from http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Rakes GC, Fields VS, Cox KE (2006) The influence of teachers' technology use on instructional practices. J Res Technol Educ 38(4):409–424

Reeves TC (1998) The impact of media and technology in schools: a research report prepared for The Bertelsmann Foundation. Retrieved from http://www.athensacademy.org/instruct/media_tech/reeves0.html

Regan T (2010) Embedding of ICT in the learning and teaching of physics: what teachers say about the use of computers in physic lessons. Sch Sci Rev 91(336):119–126

Schwartz R, Lederman N, Crawford B (2004) Developing views of nature of science in an authentic context: an explicit approach to bridging the gap between nature of science and scientific inquiry. Sci Educ 88(4):610–645

Songer NB, Lee H-S, Kam R (2002) Technology-rich inquiry science in urban classrooms: what are the barriers to inquiry pedagogy? J Res Sci Teach 39(2):128–150. doi:10.1002/tea.10013

Sweeny SM (2010) Writing for the instant messaging and text messaging generation: using new literacies support writing instruction. J Adolesc Adult Lit 54(2):121–130

Tamim RM, Bernard RM, Borokhovski E, Abrami PC, Schmid RF (2011) What forty years of research says about the impact of technology on learning: a second-order meta-analysis and validation study. Rev Educ Res 81(4):4–28. doi:10.3102/0034654310393361

Tashakkori A, Teddlie C (2006) Mixed methodology: combining qualitative and quantitative approaches. Sage, Thousand Oaks, CA

Tezci E (2011) Turkish primary school teachers' perceptions of school culture regarding ICT integration. Educ Tech Res Dev 59(3):429–433

Trumper R (2003) The need for change in elementary school teacher training: a cross-college age study of future teachers' conceptions of basic astronomy concepts. Teach Teach Educ 19(3):309–323

Trusaw M, Olson M (2010) Preservice mathematics and science teachers' inquiry into new literacy practices of the internet. J Technol Teach Educ 18(3):489–508

Wikan G, Molster T (2011) Norwegian secondary school teachers and ICT. Eur J Teach Educ 34(2):209–219

Wolsey TD, Grisham DL (2007) Adolescents and the new literacies: writing engagement. Action Teach Educ 29(2):29–38