JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898

NEW NATURAL SCIENCE LITERACIES OF ONLINE RESEARCH AND COMPREHENSION: TO TEACH OR NOT TO TEACH

Metka Kordigel Aberšek,
Kosta Dolenc,
Andrej Flogie,
Ana Koritnik

Abstract. *This study describes a research focused on science teachers' evaluation of natural science literacy of research and comprehension competence in their students. Natural science literacy of research and comprehension competence is defined as an essential part of science literacy – as a competence to find, evaluate and use science knowledge stored on the Internet (as a part of extended memory) to solve a problem in a science class and to construct students' own science knowledge. Online science literacy was defined in terms of the following aspects: basic skills (which include computer basics, web searching basics, and general navigation basics), locating information, finding a suitable website, locating the information on the website, critically evaluating the information according to its reliability and according to its relevance for the science class assessment. The data were collected through a 53-item Likert – scale questionnaire. The items were adopted from the TICA questionnaire for assessing students' general online reading competence. Science teachers from 5 different levels of pre-university education assessed their students' online science literacy in order to evaluate their students' competence to use the Internet as a storage and as a source of knowledge for teaching/learning process in the science class, to re-evaluate their online teaching practice and the need for implementation of natural science literacy of research and comprehension competence in their science curriculum.*

Key words: *ICT, Internet in natural science education, natural science literacy of research and comprehension competence.*

Metka Kordigel Aberšek, Kosta Dolenc
University Maribor, Slovenia
Andrej Flogie
Institute Anton Martin Slomšek, Slovenia
Ana Koritnik
Compulsory School Miklavž, Slovenia

Introduction

The process of shifting reading from page to screen was accompanied with the fact, "old" literacies were not suitable for reading and learning in new digital environments any more – users of online information sources and learning materials began to develop a new kind of literacy – so called *new literacy*, or, to be more precise*: new literacies.*

The term "new literacies" was introduced by Gallego and Hollingsworth (1992). In more than two decades the interpretation of the meaning of the term changed several times. The current perspective suggests that new literacy is rapidly changing and transforming – a parallel process to emerging new communication and information technologies and to changing social practices (Aberšek, Borstner, & Bregant, 2014, Aberšek, 2013). With each such change new skills are required to make use of new technologies. (Baker, 2010; Gee, 2007). "Moreover, with the Internet, literacy is not just new today; it is new every day, as additional technologies for literacy regularly and rapidly appear online" (Leu, 2014, p. 2). This changing nature of new literacies confronts the theory with the serious problem: how to describe the object (new literacy competence), if the object is permanently changing?

Recently, a dual level theory of New Literacies has been proposed to respond to this problem (Leu, Kinzer, Coiro, Castek, & Henry, 2013). It observes new literacies on two levels: the uppercase and the lowercase new literacies. *Uppercase new literacies* research is focused on new social practices Internet makes possible with technologies such as instant messaging, social networks, blogs, wikis, and e-mail (Greenhow, Robelia & Hughes 2009). *Lowercase new* *literacy theories* explore a specific area of *new literacies* and/or a *new technology* needed for social communicative transactions. One of the lowercase theories is exploring the field *of new literacies of online research and comprehension* (the term replaced the term "online reading comprehension")**.** The new literacies of online research and comprehension seek to describe what happens when we read online to learn.

Theoretical Framework

First theories tried to explain the nature of reading in Internet contexts and required the ability to flexibly reassemble existing knowledge with new knowledge applications customized to each new reading situation (Spiro, 2004). A cognitive flexibility theory claimed that older notions of knowledge domains used to interpret and predict the meaning of printed text (Anderson, 1994) no longer sufficiently explain the knowledge domains required of readers in Web-based contexts and argued (Spiro, 2004) that learning strategies working in simple domains are exactly opposite of those best for dealing with complex domains such as the Internet.

Later research rejected this theory. Reading was confirmed as an active, constructive, meaning-making process, in which readers actively construct meaning, as they interact with. Expert readers use a range of strategic cognitive processes to select, organize, connect, and evaluate what they read. These strategies include asking questions, developing connections (Jesenšek, 2011), and making inferences (Pressley & Afflerbach, 1995). In addition, readers use their existing knowledge to more clearly understand ideas and information in texts, make predictions about what might come next, and reason strategically when they have difficulties in the process of comprehension. Use of informational texts requires readers to attend to structural text features, and evaluate the relevancy of the text in relation to the task (Dreher, 2002; Goldman & Rakestraw, 2000).

According to the *new literacies of online research and comprehension,* these strategies play an important role in online reading comprehension too. But they are almost not sufficient for successful searching for information and for using the Internet as a source of knowledge in the ICT supported science class, since Internet text differs from linear text in many ways (Dolenc, & Aberšek, 2015). Internet is an open network system "a kind of informational environment in which textual materials and ideas are linked to one another in multiple ways" (Burbules & Callister, 2000, p. 43). Links embedded within hypertext systems are constructed so that readers must select a target location in order to move through the text. Moreover, hypertext makes explicit and external a range of possible interconnections between texts and guides the conception of readers who can not only follow embedded connections created by the author but also construct their own personal pathways through multiple texts. The Internet "text"/site usually contains outside advertisements, links that change from one day to the next, or pathways to information that are completely outside the realm of its intended purpose. Internet texts are part of a complex open-ended information system that changes daily in structure, form, and content. They offer distracting advertisements, inconsistent text structures, broken links, and access to an infinite amount of information completely unrelated to their intended reading purpose. And last, but not unimportant: Internet texts are combined in complex ways (Coiro & Dobler, 2007) and are often intermingled with hidden social, economic, and political messages (Leu & Kinzer, 2000).

New school agendas all over the world recommend Internet "text" as a knowledge source and as a source of information – and natural science didactics seem to be more open to the concept than social science didactics, which remains far more attached to traditional linear sources of knowledge. And all that without considering the open question of prerequisite for such shift from page to screen and from linear to networked text structure – *the new literacy of online research and comprehension*.

Current (qualitative) research (Coiro, 2007; 2011; Leu et al., 2008) brought light to metacognitive processes and inferential reasoning processes expert e-readers are using by their successful reading of e-texts, explained the role of pre-knowledge in this process and why they contribute to better comprehension online. According to these findings, the *new literacy of online research and comprehension* is structured and contains in the frame of each structural element skills, very similar to those particularly useful in the process of linear reading, and additional complexities needed for Internet comprehension.

ISSN 1648–3898

Table 1. Similarities and differences between linear and Internet text readings (Adopted after Coiro & Dobler, 2007).

Reading comprehension strategies	Similarities between linear and open hypertext reading	Additional complexities, needed in open hypertext comprehension processes
Pre knowledge	– pre knowledge of the topic • knowledge • misconceptions • vocabulary (general, specific) – pre knowledge of printed informational text structures	– prior knowledge of hypertext structure / website structure; – prior knowledge of Web-based search engines - basic skills • computer basics, • navigational basics • Web searching basics
Inferential reasoning	– creating coherence: • text based coherence • general representation (situation model) – inferential reasoning strategies: • literal matching skills • structural cues • context clues	– forward inferential reasoning; – multilayered reading process across hypertext structure and three dimensional Internet spaces
Metacognitive/ self-regulated processes	– conventional metacognitive strategies for comprehension monitoring and repair; – connected components of a larger strategic reading process; – self regulated recursive circle	– self-regulated recursive circle intertwined with physical reading actions (typing, clicking, scrolling, dragging); – rapid information-seeking cycles within extremely short text passages

Inferential reasoning is a central component of skilled reading (Garnham & Oakhill, 1996). It is the ability to read between the lines while making connections not explicitly stated in the text. Readers with sufficient prior knowledge, make more inferences than less knowledgeable readers in order to facilitate their comprehension of informational text.

Let us examine the process of inferential reasoning more closely. The most recognized theory that explains this topic is a *C-I model of text comprehension* (Kintsch, 1988; van Dijk & Kintsch, 1978). Although Kintsch model has been developed in the 1980s, it is still used for predicting the comprehension of text based knowledge – also on the Internet. In the Kintsch model, the reader's memory of the text is represented at 3 levels: representation of the words and sentences, the meaning of the text (textbase), and a general representation of what is described by the text incorporating outside background knowledge (situation model). In the frame of explanation text, the typical textform in science education, which is based on facts and used to explain the sequence, cause and effect of an event, the information, called propositions, are connected. Such connections are called *semantic coherence relations*.

Propositions that have overlapping arguments are semantically related and create ***coherence***. In cases, when the proposition, processed in the particular moment, does not share arguments with propositions in *short-term memory*, the reader must create a ***bridging inference –*** with the aim to maintain coherence (Kintsch & van Dijk, 1978). For such creation of bridging inference, the reader must use his pre knowledge in order to fill in the missing information.

This is the reason why for learning from the Internet a skilled learner needs additional inferential reasoning skills. Coiro and Dobler (2007) speak of *specific complexities of inferential reasoning required in Internet contexts*. In their experiment they observed two types of specific inferential reasoning in the process of learning from Internet: forward inferential reasoning and a multilayered inferential reasoning process. They report "the nature of Internet text appeared to prompt a high incidence *of forward inferential reasoning* (e.g., predictions) beyond the level typically involved in the comprehension of printed informational text" (Coiro & Dobler, p. 233). They found evidence to suggest that skilled readers in our study appeared to make forward inferences (e.g., predictions) within Internet text each time they were confronted with one or more hyperlinks on a given page. Also, they observed skilled readers, combining their use of traditionally conceived inferential reasoning strategies with a new understanding that the relevant information may be "hidden" beneath several layers of links on a website as opposed to within one visible layer of information in a printed book. Comprehending Internet texts encourage readers to anticipate their understanding through *multiple layers* that are almost always hidden from view, demands many more attempts to infer, predict, and evaluate reading choices (e.g., hyperlinks followed) while anticipating the relevance of information in an open information space multiple levels beyond a visible link.

Successful learning from Internet text is essentially linked with ***metacognitive strategies*** for comprehension monitoring and repair. As predicted, conventional metacognitive reasoning and additional metacognitive complexities contribute to find and process the information and to construct coherent knowledge. Among these additional metacognitive complexities is a self-*regulated recursive circle* connected with physical reading actions such as typing, clicking, scrolling and dragging. Every time a reader is moving the mouse, a circle is initiated: planning, predicting, monitoring, evaluating. And, parallel to the next move, a regulated recursive circle is generated again and again. Searching and learning process on the Internet is conditioned with the competence of using these rapid information-seeking circles within extremely short text passages.

As in conventional linear literacy ***pre knowledge*** is a prerequisite for inferential reasoning and metacognitive processes in reading and learning from Internet texts. In linear text *the author* creates a line of coherent arguments through the text, then makes words and sentences flow together through common referents. This helps the reader in structuring the information in the text to fit into the knowledge structures of what has been read previously. Differently, Internet text does not help the reader with the carefully selected order of information. This, as Foltz (1996) points out, is the main problem connected with hypertext comprehension on the Internet. It is essential for the hypertext structure that in any text section in a hypertext, there are usually a variety of other sections to which a reader can jump. This freedom of choice can cause difficulties in comprehension process concerning finding the coherence. In the reading process of hypertext it is impossible to predict what the reader will read first and what he is going to read next. Consequently, it is impossible to equip the reader with the information he would have needed in the short term memory to find the coherence with the information he is reading at the contemporary moment. It is not possible for the author of the Internet text to anticipate all the possible places to which a reader may jump and therefore, it is also not possible to maintain good macro coherence for all possible links. Incoherent jumps result in additional processing load for the reader. In such cases the reader generates the necessary inferences to incorporate the textual information from the new node into what has been previously read. The consequence of variety of the possible links in a hypertext is the smaller amount of propositional overlap. This corresponds to a smaller amount of coherence of the text reception on the reader's side and may cause difficulty in the reader's comprehension – simply because the reader must create more bridging inferences. *If readers don't have the proper pre knowledge, these inferences cause an additional mental workload for the reader. The consequence of this is lower comprehension.*

But only pre knowledge of the topic and vocabulary (Koletnik, 2013) is not sufficient for successful comprehending of the Internet text. According to Coiro & Dobler (2007), there are two additional sets of pre knowledge: pre knowledge of informational website structures and pre knowledge of Web based search engines.

Pre knowledge of informational website structures to guide their reading on the Internet is essential in the process of navigating a web site, for recognizing and negotiating hierarchical and non-linear hyperlinks, navigational icons, interactive multimedia, and browser toolbars (Bilal, 2000; Eagleton, 2003). Every time a user opens a new website, he needs time to find out the internal logic of its structure, learns to recognize visual signals for its linear and nonlinear links, to find out what a particular navigation icon means, to see which multimedia connections are offered for additional information on the topic and – not unimportant – how the interruptions (advertisements, non-relevant links) are marked. The navigation will be easier the next time the user opens this website. He will remember, what he has learned about its structure, and this knowledge will help him to find the needed information more quickly. After longer experience with different websites, the user will be able to adapt very quickly to the structure of any new websites, since they are usually structured according to some general rules. Coiro and Dobler research (2007) reviled, skilled Internet readers possess important sources of knowledge about the structure and organization of informational websites that forms the decisions they make during online comprehension.

Pre knowledge of Web based search engines involves understanding the processes of browsing, selecting appropriate search engines, formulating keyword searches, negotiating subject hierarchies, and evaluating annotated search results (Bilal, 2000). A closer look at this knowledge shows three areas where this knowledge is stored. The first includes the so-called computer basics, such as turning the engine on/off, following the cursor with the eyes, using the mouse, logging in/out, using a word processor, creating a new file. The second includes basic knowledge for finding informa-

ISSN 1648–3898

tion on the Internet: how to formulate the key words, where to write them on the web site, how to narrow or widen the search process. And the third includes knowledge on how to navigate in open hypertext on the World Wide Web and how to evaluate what has been found – which criteria to use to decide whether the information is reliable (and can be used for school work) or not.

Based on Coiro and Dobler findings (2007), in later research Leu et al. (2013) suggested that at least five processing practices occur during online research and comprehension: a) reading to define important questions; b) reading to locate online information; c) reading to critically evaluate online information; d) reading to synthesize online information, and e) reading and writing to communicate online information.

Online reading comprehension always begins with a *question or a problem*. This is an important source in the differences between online and offline reading comprehension. It is known that the new literacies of online reading comprehension occur within a process that includes the skills and strategies required to identify an important question directing the reader to locate, critically evaluate, synthesize, and communicate information with the Internet (Leu et al., 2008). Users read on the Internet to solve problems and answer questions. How a problem is framed or how a question is understood is a central aspect of online reading comprehension.

Locating information online is another aspect of online reading comprehension. It also requires new online reading comprehension skills such as using a search engine, reading search engine results, or quickly reading a web page to locate the best link to the information that is required. Many students lack these skills. Of those who do use a search engine, for example, many do not appear to know how to read search engine results, instead they click down the list of links in a "click and look" strategy (Leu et al., 2008). Locating information during the online reading comprehension process may create a bottleneck for the subsequent skills of online reading comprehension (Henry, 2007). That is, those who possess the online reading comprehension skills necessary to locate information can continue to read and solve their problem; those who do not possess these skills cannot. In fact, this bottleneck may contribute to the lack of isomorphic performance between online and offline readers.

Another area in which online reading comprehension requires a unique set of skills is during **critical evaluation**. Whereas critical evaluation is important when reading offline information, it is perhaps more important online, where anyone can publish anything; knowing the stance and bias of an author becomes paramount to comprehension and learning. Determining this in online contexts requires new comprehension skills and strategies (Bregant, Stožer, & Cerkvenik, 2010).

Successful online research and comprehension also requires the ability to read and to **synthesize online information from multiple online sources**. Synthesis or integration of separate and unique ideas is recognized as the most demanding part of the offline comprehension process. In reading on the Internet it becomes even more demanding. The Internet introduces additional challenges for coordinating and synthesizing enormous amounts of information presented in multiple media and in multiple media formats from nearly unlimited sources (Leu et al., 2014).

A final component of successful online research and comprehension is the ability *of reading and writing to communicate online information* via Internet, while interacting with others to seek for more information or to share what you have learned (Leu et al., 2014).

In summing up all this theoretical background, we can repeat, what we have already mentioned: expert readers use, for reading on the Internet, a range of strategic cognitive processes to select, organize, connect, and evaluate what they read. These strategies include asking questions, developing connections, and making inferences, evaluating and synthesizing, what they have found, into a coherent knowledge about the topic and/or the research question.

The Aim of the Research

Theoretical background brings us to the central question of the study, which was implemented in spring 2015 in Slovenia: to what extent are students in compulsory and secondary education prepared for the shift from "page to screen", or, to be more precise, are they competent for online research and comprehension and what is the level of their new natural science online research and comprehension literacy. Therefore, the study examined compulsory and secondary school natural science teachers' assessment of their students' *new natural science literacies of online research and comprehension competence.*

Research Methodology

General Background of Research

The central question of the research was to find out: are students, who all belong to a "Z generation", the so called "digital natives", online research and comprehension competent. Are they all prepared for a total switch to online learning and to exclusively ICT supported natural science teaching paradigm? This question is very important, since new school agendas all over the world recommend Internet "text" as a knowledge source and as a source of information – and natural science didactics seem to be more open to the concept than social science didactics. In this context the opinions on the competence in new literacies of online research and comprehension are strongly divided: some were convinced, the Z generation is totally competent for Internet communication, also for gaining and sharing new knowledge, and others (more detailed research), who warn, the digital natives, at least some of them, have in the process of learning online remarkable difficulties, which will greatly decrease their learning results, if the switch from conventional to ICT teaching paradigm will happen too soon and without differentiation according to the level of their online research and comprehension literacy competences.

Four research questions were examined to reveal the answer to the central question of the study: 1. How do natural science teachers assess their students' competence of basic online skills (computer basics, web searching basic, navigation basics)? 2. How do natural science teachers assess their students' competence for locating information by using a search engine? 3. How do natural science teachers assess their students' competence of web site navigation? 4. How do natural science teachers assess their students' competence of evaluation of research results?

Sample Selection

A sample comprised 70 elementary and natural science teachers, 48 of them were compulsory school teachers and 22 upper secondary teachers. In the Slovene school system compulsory school (9 years) is divided into 3 periods, called trienniums. In the first triennium (age 6 – 8) and in the first two years of 2nd triennium (age 9 – 11) natural science is taught by elementary teachers in the last year of 2nd triennium and in the 3rd triennium (12 – 14), natural science is taught by biology, physics, chemistry, geography teachers and teachers for science and technology. At the upper secondary level natural science is taught by subject specialists. The sample of (48) compulsory teachers was divided into three groups according to triennium, where they teach. This part of the sample consisted of 22 natural science teachers from the gymnasium upper secondary program. Such sample was selected because: it covered all groups of pre university education from the age of 6, where it was examined, the Z generation really enters the school system online research and comprehension literacy and consequently does not need teachers assistance in this matter, to the secondary education, where the intent was to find out if all members of Z generation develop online research and comprehension literacy in the present form of pre university education.

Instrument and Procedures

Data were collected through 53 – item Likert-scale questionnaire. The items were adopted from TICA Checklist, developed in Teaching Internet Comprehension Skills for Adolescents project, which was focused on studying skills, essential to online reading comprehension (Leu et al., 2008). The original TICA checklist of online reading comprehension contained items from 5 areas, required during online reading comprehension: understanding and developing questions, locating information, critically evaluating information, synthesizing the information and communicating the information. The adaptation, used for our research, focused on computer basics (Appendix A in the original survey) and on locating information by using a search engine (finding the useful web site), navigating a web site and evaluating the results of research (Appendix B in the original survey). Also the number of items was reduced – in the checklist for computer basics from 29 to 21, in the checklist for locating information by using a search engine from 26 to 15, in the checklist for navigating a web site from 8 to 7 and in the checklist evaluating the results of research (evaluation and reliability) from 16 to 10. The survey, used in the research did not contain questions about the competence for generating questions, synthesizing information and communicating information.

The questionnaire was handed out to groups of teachers, above defined. In the four compulsory schools, where data were selected, an assistant researcher handed out the questionnaires personally. A short motivational

ISSN 1648–3898

conversation followed: the purpose of this conversation was to motivate teachers to pay attention to the questionnaires and to focus on the topic for the whole duration of answering the items in question. At the secondary level, the school headmasters were asked to hand out the questionnaires at the pedagogical conference, where all teachers were gathered, and to motivate them to focus on the questionnaire. On this occasion the headmaster stated that the results of the research will be valuable for the next teaching practice.

The questionnaire for teachers had a following introduction: *In a contemporary school it was declared, memorizing knowledge is not needed anymore, the so called knowledge in the digital world is available on the Internet and always "just a click away". In this context, one should focus on the questions: "Are all our students competent to use Internet as a learning source, and for storing knowledge?" Are they really competent to find the information/knowledge at the moment, when it is needed? Or in short: IS IT TRUE THAT THE GENERATION X ENTERS THE SCHOOL AS DIGITALLY/ONLINE LITERATE?* In the following text teachers were asked to evaluate online literacy of their students. Elementary teachers' questionnaire included also the guideline that they should evaluate their students' online literacy in the teaching situation in the natural science class.

Data Analysis

Quantitative data of elementary teachers and natural science teachers were collected. After verifying that data were free of errors, quantitative analyses were conducted and analyzed according to the following phases, or by: encoding, defining and organizing the data and interpreting the results. For statistic processing of the data an IBM SPSS program was used. For the basic statistic interpretation of the results mean and standard deviation values of the data were used.

Results of Research

Table 2 shows mean values and standard deviation values of natural science teachers' and elementary teachers' evaluation of their students' online basic skills, computer basic skills, web searching basic skills and their general navigation basic skills.

In general, upper secondary teachers evaluated that their students were quite proficient in all 26 computer basic skills, listed on the checklist for computer basics. Only two items scored lower than M=4.50: item "open programs and files using icons and/or the Start Menu (PC)" scored 4.36 (S.D.=0.83) and item "Open a new tab" scored 4.23 (SD=0.83). All other items scored between 4.50 (SD=0.95) and 4.95 (SD=0.97). On the other side, teachers of 1st triennium evaluated the skills of their students' computer basics as very low: if we frame out the result that almost all students can turn on the computer and use the mouse/track (M=4.41 and M=4.31) and the fact that almost all of them can follow the class/school rules for computer use (which is not strictly a computer basics), remains the fact that teachers evaluated all other components of computer basics skills between M=1. 65 (SD=0.87) and M=2. 88 (SD=0.82).

Table 2. Check list 1– online basic skills.

	1st		2nd		3rd		Gymnasium	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
1. Computer Basics								
Turn a computer on/off	4.41	1.07	4.60	1.19	4.8	0.89	4.95	1.04
Use the mouse/track pad	4.35	0.91	4.8	1.04	4.8	0.79	4.86	1.04
Follow classroom and school rules for computer use	3.47	1.14	3.8	0.99	4.19	0.89	4.45	0.99
Open programs and files using icons and/or the Start Menu (PC)	2.88	0.82	4.47	0.83	3.88	0.85	4.36	0.83
Create/open a new folder/file	1.94	0.95	3.2	0.91	4.12	0.95	4.68	0.80

	1st		2nd		3rd		Gymnasium	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
Launch a word processor	2.06	0.84	3.93	1.14	4.25	0.93	4.77	0.88
Open a word processing file	1.88	0.97	2.87	0.82	4.12	1.05	4.77	0.87
Type a short entry in a word processing file	2	0.83	3.27	0.95	4.19	0.88	4.41	1
Copy text	1.76	1.23	3.4	0.91	4.31	1.19	4.73	0.89
Cut text	2.24	1.04	3.8	0.84	4.44	1.19	4.77	0.93
Past text	1.82	1.01	3.33	0.97	4.88	1.04	4.77	1.06
Name a word processing file and save it	1.71	0.97	3.6	0.83	4.63	0.99	4.77	0.84
Open a new window	2.24	1.13	3.53	1.23	4.25	0.83	4.73	0.97
Open a new tab	1.65	0.87	2.8	1.04	3.56	0.80	4.23	0.83
2. Web Searching Basics								
Locate and open a search engine	2	0.85	4.27	1.07	4.69	0.89	4.95	0.97
Type key words in the correct location of a search engine	2.71	0.91	4.67	0.91	4.69	0.85	4.82	1.13
Use the refresh button	1.94	1.14	4	1.14	3.71	0.95	4.5	0.87
Use the “BACK” and “FORWARD” buttons	2.65	0.82	3.67	0.82	4.38	0.93	4.82	0.89
3. General Navigation Basics								
Maximize/minimize windows	2.18	0.7	3.73	0.7	4.88	1.19	4.5	0.95
Open and quit applications	2.76	0.81	3.93	0.81	4.5	1.05	4.95	0.93
Toggle between windows	2	0.89	3.4	0.89	4.06	0.88	4.82	1.05

The results of the Checklist 1 could be understood as the answer to the question: do the digital natives enter the school computer literate: The answer is: no, they do not, even more, almost all of them can turn on and off the computer and use the mouse/track pad, what they probably had learned using digital devices for play/fun, but a great majority of them doesn't possess other 21 computer basics, they would have needed for searching and learning with the help of digital engines.

Table 3 shows that elementary and natural science teachers evaluate their student's competences for searching for a proper website for information and learning as remarkably lower than their computer basics competences.

Table 3. Checklist 2 – Locating information by using a search engine /searching for a proper website.

	1st		2nd		3rd		Gymnasium		
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD	
1. Locate at least one search engine.		2.76	1.06	3.33	0.89	4.88	0.93	4.77	0.83
2. Use several of the following general search engine strategies during key word entry:									

 ISSN 1648–3898

	1st		2nd		3rd		Gymnasium		
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD	
topic and focus		1.94	0.97	3.33	0.95	3.5	0.91	4.09	0.88
single and multiple key word entries		2.29	0.83	3.6	0.93	4.38	1.14	4.23	0.87
phrases for key word entry		1.47	1.23	3.13	1.05	3.5	0.82	4.09	1
3. Use several of the following more specialized search engine strategies during key word entry:									
quotation marks		1.24	1.01	2.33	1.19	2.63	0.91	3.41	0.87
paraphrases and synonyms		1.24	0.97	3	1.19	2.56	1.09	3.41	0.89
Boolean (and/or/nor)		1.18	0.93	2.07	1.01	2.44	0.7	3.13	0.79
4. Read search engine results effectively to determine the most useful resource for a task using strategies such as:									
Knowing which portions of a search results page are sponsored; containing commercially placed links, and which are not.		1.41	0.84	2.06	0.79	3.06	1.19	3.86	0.85
Skimming the main results before reading more narrowly.		1.24	0.97	2.53	0.89	3.06	1.19	3.82	1.04
Reading summaries carefully and inferring meaning in the search engine results page to determine the best possible site to visit.		1.41	1.13	2.2	0.85	2.38	1.01	3.36	1.04
Understanding the meaning of bold face terms in the results.		1.35	0.87	2.87	0.95	2.94	0.91	3.55	0.99
Understanding the meaning of URLs in search results (.com, .org, .edu, .net).		1.24	0.89	2	0.93	2.31	1.02	3.55	0.83
Knowing when the first item is not the best item for a question.		1.65	0.79	2.6	1.07	2.63	0.93	2.91	0.80
Knowing how to use the history pull down menu.		1.24	0.89	2.4	0.91	2.63	0.79	3.64	0.88
5. Bookmark a site and access it later.		**1.35**	**0.93**	2.6	**1.14**	2.63	**0.89**	3.23	**0.87**

Upper secondary teachers expressed quite a great confidence in their students' competence to locate at least one search engine (M=4.77; SD=0.83) similar as 3rd triennium teachers (M=4.88; SD=0.93), but observing the competence of using search engine strategies and specialized search engine strategies, the difference between gymnasium (age 14 – 18) and 3rd triennium (age 11-13) is noticeably larger. And also, comparing the results in general search strategies (topic and focus, single and multiple key word entries, phrases for key word entry) and specialized search engine strategies (quotation marks, paraphrases and synonyms, Boolean) shows, that many of gymnasium students in their teachers' evaluation could not use the specialized ones. The difference between gymnasium students and 3rd triennium students is even larger when compared to the competence of reading search engine results effectively. 3rd triennium students scored between M=2.31 (SD=1.02) and M=3.06 (SD=1.19) and gymnasium students between M=2.91 (SD=0.80) and M=3.86 (SD=0.85). Observing the results of the teachers' evaluation of 1st and 2nd triennium students' competence for location the information by searching for the proper website, it could be said that this competence is not developed enough for implementing Internet as a learning source in the natural science education in the first half of compulsory school – at least not as a frontal didactical tool for all students.

Table 4 shows, that elementary and natural science teachers evaluate their students' competences for navigating a website for information and learning lower than their computer basics competences and similar to their competence for searching for a proper website.

Table 4. Check list 3 – navigation on the web site.

	1st		2nd		3rd		Gymnasium	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
NAVIGATION on a Web site								
Quickly determine if a site is potentially useful and worth a more careful reading	1.06	0.87	2.53	0.95	3	1.13	3.41	1.05
Read the site more carefully to determine if the required information is located there.	1.47	1	2.6	0.91	2.94	0.87	2.91	0.88
Predict information behind a link accurately to make efficient choices about where information is located.	1.29	0.89	2	1.09	2.31	0.89	2.86	1.19
Use structural knowledge of a web page to help locate information, including the use of directories.	1.29	0.93	2.13	0.7	2.69	0.79	4.5	1.19
Know how to open a second browser window to locate information, without losing the initial web page.	1.53	1.06	2.53	0.83	3.19	0.89	4.09	1.01
Know how to use an internal search engine to locate information on a site.	1.59	0.81	2.2	1.23	2.88	0.83	3.77	0.97
Monitor the reading of a web page and know when it contains useful information and when it does not.	1.47	0.89	2.33	1.04	3	1.23	3.36	1.13

Upper secondary teachers expressed high confidence that their gymnasium students' knowledge of the text structure and the competence for using it in the process of navigating the website (M=4.50; SD=1.19), on the other side, 1st triennium teachers expressed that their students have no such knowledge – so they cannot use it for navigation of the site. Table 3 shows the dynamics of the development of this competence. Observing this dynamic shows that less than a half of the students between 12 and 14 can use knowledge of text structure for navigating the website. The lowest scored competence in the group of navigational competences was the competence to predict information behind a link, in order to make efficient choices where information is located (M=2.86; SD=1.19 for gymnasium students). This means that even at the doorstep of the university, according to the opinion of their teachers, more than a half of students are not capable of multilayered inferential reasoning process, which is essential for searching and locating information on the Internet.

Table 5 shows that elementary and natural science teachers evaluate their students' competences for critically evaluating information in the process of learning significantly lower than their computer basics competences and slightly lower than their competence for navigating the chosen website.

The competence for critical evaluation of information/knowledge, found on the website, is in the teachers' opinion quite low. Even at the age 15 – 18 just little over a half of students can identify, evaluate, and recognize that all websites have an agenda, perspective, or bias and identify and evaluate bias, given a website with a clear bias (M=3.59). And the same amount of students know that Wikipedia is not a perfect portal of information when they search for information or knowledge for their natural science assignments. The lowest developed competence is the competence to use the fact that the broken links are a sign of an unreliable website (M=2.86). This can be explained in connection with the absence of competence for using knowledge about the website structure, presented in Table 3. By observing the results of compulsory school students, it can be concluded, that the competence for evaluating what is reliable information and what not, is not sufficiently developed in order to use the Internet as an information source in natural science class, without the teachers' didactical guidance.

ISSN 1648–3898

Table 5. Check list 4 Evaluation of the information on the web site.

	1st		2nd		3rd		Gymnasium	
	Mean	SD	**Mean**	SD	**Mean**	SD	**Mean**	SD
Critically Evaluate Information								
Identify, evaluate, and recognize that all websites have an agenda, perspective, or bias and identify and evaluate bias, given a website with a clear bias.	1.59	0.91	2.53	0.83	3.19	1.13	3.59	0.83
Identify and evaluate the author of a website whenever visiting an important new site.	1.05	1.09	1.87	1.23	2.31	0.87	2.86	0.80
Identify several markers that may affect reliability, such as:								
• Is this a commercial site?	1.29	0.81	1.87	1.01	2.44	0.79	3.14	0.87
• Is the author an authoritative source (e.g., professor, scientist, librarian, etc.)?	1.78	0.89	1.73	0.97	2.44	0.89	3	1
• Does the website have links that are broken?	1.00	0.97	1.6	0.95	2.94	0.85	2.86	0.89
• Does the information make sense?	1.59	0.78	1.87	0.93	2.5	0.95	3.18	0.93
• Does the author include links to other reliable websites?	1.29	1.14	1.87	1.05	2.5	0.93	3.41	1.06
• Does the website contain numerous typos?	1.35	0.82	1.47	0.88	4.19	1.05	3.05	0.84
• Do the images or videos appear to be altered?	1.41	0.95	1.8	1.19	2.81	0.97	3.36	0.97
Understand that Wikipedia is a reasonable, but imperfect, portal of information	1.53	0.91	2.6	1.19	2.81	1.13	3.59	0.83

The results, presented in tables 2 – 5, answer the central question of the presented research: Are students, who all belong to a "Z generation", the so called "digital natives", online research and comprehension competent? Are they all prepared for a total switch to online learning and to an exclusively ICT supported natural science teaching paradigm? The results of the present research reveal that the X generation, generation of digital natives, does not enter school as digitally literate, and above all, that it does not have the ***new natural science literacies of online research and comprehension competence.*** This competence is a very structured competence, and the particular elements have, as the present research shows, different dynamics. If we can say, that the *basic computer skills* are sufficiently developed during the pre-university education, we cannot oversee, that competences *searching for a proper website*, *navigating the website* and *critically evaluating the results found on the web site* develop much later. At the beginning of the compulsory school they are practically nonexistent and they develop slowly during the next 13 years – in just slightly more than half of the population. After realizing this, a following conclusion should be considered: natural science literacies of online research and comprehension competence should be methodically developed and should become a part of general and special natural science curricula.

Discussion

The results of the study must be considered in the context of several studies, which have investigated and compared the effectiveness of online learning/reading and offline learning – and their results, which have almost as a rule shown the difficulties weak students will have, by switching from offline to online too soon – before they are ready. Hill and Hannafin (1997) have explored the cognitive strategies used by adult learners on the Internet and found that metacognitive strategies, prior knowledge of subject and Internet text systems, and perceived self-efficacy influenced their ability to interact with and learn from Internet text. Others have explored the nature of Internet search strategies among students in K-12 classrooms and found numerous obstacles in information seeking with open Internet text environments. Readers on the Internet experienced challenges associated with ineffective and inefficient search processes (Bilal, 2000; Eagleton, 2003), cognitive overload and disorientation (DeStefano, & LeFevre, 2007), a tendency to drift from one search question to another (Lyons, Hoffman, Krajcik, & Soloway, 1997), and an inability to know how to use the information once it has been located (Wallace, Kupperman, Krajcik, & Soloway, 2000, Coiro & Dobler, 2007)). Also, A. Mangens' research of learning results gained by reading linear and online text showed significantly weaker results when students tried to gain knowledge from screen, even more, if studying time was limited (Mangen, 2012). She explained such results in relation to issues with navigation within the document and the necessary scrolling, which is inevitable when reading longer documents. Similarly DeStefano and LeFevre (2007) point out that hypertext confronts students with an additional cognitive load – and underline, readers with high prior knowledge are typically unaffected when the text structure was nonlinear and had many imbedded links. On the other hand, students with weaker knowledge needed the guidance to comprehend the information delivered by the information of the hierarchical structure of the text. DeStefano and LeFevre concluded their research with a warning: students with lesser abilities need guidance in learning from hypertext, especially when hypertext is not optimally structured, when the choices are totally free (if they are not limited by nodes) – and the Internet texts as a rule do not contain restricted possibilities in the process of navigation between the links. The information gaps between information are for low pre-knowledge learners too wide in order for them to build inferential bridges between them and to construct text coherence and – consequently comprehension. To sum up, previous research and results of the present study agree, not all students would benefit from introducing ICT supported education Pulko, Zemljak 2013), especially from implementing (not didactically remodeled) open hypertexts – which is a typical text structure on the internet. Internet text structure confronts the reader with additional cognitive load and additional stress, which hampers reading comprehension and the process of learning.

And what does this mean for natural science class?

Reading and reading comprehension is an important gateway for learning and succeeding at school. There are remarkable differences in off line reading: among students. According to Leu et all. (2014) American results show in both the 2011 and the 2013 National Assessment of Educational Progress (NAEP) for reading, a difference of two thirds of a standard deviation in scaled reading scores between eighth-grade students eligible for the National School Lunch Program and those who were not (NCES, 2011b, 2013). The difference favored economically advantaged students. This is roughly the difference between scores at the 25th percentile and the 50th percentile (see NCES, 2011b , 2013) or two to three years of schooling in the middle school and high school years (Hill, Bloom, Black, & Lipsey, 2008).

This difference in reading performance had – statistically confirmed – serious consequences on learning science (Leu et al., 2014). Differences in science achievement had been measured: In the 2009 NAEP for science, there was a difference of nearly one standard deviation between eighth grade students eligible for the National School Lunch Program and those who were not. This represents a difference between scoring at the 20th percentile and the 50th percentile (NCES, 2011a) or two to three years of schooling in the middle school and high school years (Hill et al., 2008).

The score difference in reading performance and its influence on learning science were – as mentioned – calculated for the process, when students used traditional offline – linear learning materials. But what would have happened, if natural science teachers would implement e-didactical materials and knowledge on the Internet for all students at the same time – without any differentiation? According to Leu et al. (2014) the learning achievements are, when reading online, even more correlated with reading comprehension results.

Conclusions

The new school agendas all over the world recommend Internet "text" as a knowledge source and as a source of information – and natural science didactics seem to be more open to the concept than social science didactics. But, as recent research, including presented study, reveals that at least half of digital natives have in the process of learning online remarkable difficulties, which will seriously, decrease their learning results, if the switch from conventional to ICT teaching paradigm will happen too soon and without differentiation according to the level of their online research and comprehension literacy competence. Digital natives, despite the fact that they are growing up in an online world and spending thousands of hours in online gaming, texting and socializing, have limited skills in computer basics and even more limited skills in searching for the information on the Internet, navigating websites

ISSN 1648–3898

and evaluating the information they have found. Previous research, as well as the results of this study, suggests that instruction in online research and comprehension should be included in literacy curriculum (OECD, 2010) and that natural science research and comprehension competence should be included into the curricula of every natural science subject at all levels of the school system.

Note

This paper was presented at the 1st International Baltic Symposium on Science and Technology Education (BalticSTE2015) 'State-of-the-Art and Future Perspectives', 15-18 June 2015, Siauliai, Lithuania. It was approved by the Symposium scientific committee and recommended for publication in *Journal of Baltic Science Education*. A short version of this paper is published in the symposium proceedings (https://www.academia.edu/13101334/STATE-OF-THE-ART_AND_FUTURE_PERSPECTIVES).

References

Aberšek, B., Borstner, B., & Bregant, J. (2014). The virtual science teacher as a hybrid system: Cognitive science hand in hand with cybernetic pedagogy. *Journal of Baltic Science Education*, *13* (1), 75-90.

Aberšek, B. (2013). Cogito Ergo Sum Homomachine? *Journal of Baltic Science Education*, *12* (3), 268-270.

Alvermann, D. E., Hutchins, R. J., & McDevitt, R. (2012). Adolescents' engagement with Web 2.0 and social media: Research, theory, and practice. *Research in the Schools*, *19* (1), 33 – 44.

Anderson, R. (1994). Role of readers' schema in comprehension, learning, and memory. In Ruddell, R.B, Ruddell, M.R. & Singer, H. (Eds.), *Theoretical models and processes of reading* (4th ed., pp. 448-468). Newark, DE: International Reading Association.

Baker, E. (2010). *The new literacies: Multiple perspectives on research and practice*. New York, NY: Guilford.

Bilal, D. (2000). Children's use of the Yahooligans! Web search engine: I. Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science*, *51*, 646-665.

Bregant, J, Stožer, A, & Cerkvenik, M. (2010). Molecular reduction: reality or fiction? *Synthase*, *172*, 437-450.

Burbules, N. C., & Callister, T. A., Jr. (2000). *Watch IT: The risks and promises of information technologies for education*. Boulder, CO: Westview.

Dolenc, K., & Aberšek, B. (2015). TECH8 intelligent and adaptive e-learning system: Integration into technology and science classrooms in lower secondary schools. *Computers & Education, 82* (0), 354-365.

Dreher, M. J. (2002). Children searching and using information text: A critical part of comprehension. In C.C. Block, M. Pressley (Eds.), *Comprehension instruction: Research-based best practices,* (289-304). New York: Guilford.

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. *Reading Research Quarterly*, *42* (2), 214–257.

Coiro, J. (2011). Predicting reading comprehension on the Internet: Contributions of offline reading skills, online reading skills, and prior knowledge. *Journal of Literacy Research, 43* (4) 352-392. http://jlr.sagepub.com/content/43/4/352.full.pdf+html.hzt67.

DeStefano, D., & Le Fevre, J. A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*, 1616–1641.

Eagleton, M. B. (2003, December). *Essential literacies in the digital age: Adolescents' Internet inquiry strategies*. Paper presented at the 53rd annual meeting of the National Reading Conference, Scottsdale, AZ.

Foltz, P. W. (1996). Comprehension, coherence and strategies in hypertext and linear text. In Rouet, J. F., Levonen, J. J., Dillon, A. P., & Spiro, R. J. (Eds.), *Hypertext and cognition*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Gallego, M., & Hollingsworth, S. (1992). Multiple literacies: Teachers' evolving perceptions. *Language Arts*, *69* (3), 206 – 213.

Garnham, A., & Oakhill, J. V. (1996). The mental models theory of language comprehension. In Britton, B.K. & Graesser, A.C. (Eds.), *Models of understanding text* (313-339). Hillside, NJ: Erlbaum.

Goldman, S. R., Wiley, J., & Graesser, A. C. (2005). *Literacy in a knowledge society: Constructing meaning from multiple sources of information*. Paper presented at the annual meeting of the American Educational Research Association, Montreal, QC, Canada.

Greenhow, C., Robelia, B., & Hughes, J. (2009). Web 2.0 and classroom research: What path should we take now? *Educational Researcher*, *38* (4), 246 – 259 .

Henry, L. A. (2007). Exploring new literacies pedagogy and online reading comprehension among middle school students and teachers: Issues of social equity or social exclusion? (Doctoral dissertation). Retrieved from: www.digitalcommons.uconn.edu/dissertations/ AAI3282520.

Hill, J., & Hannafin, M. (1997). Cognitive strategies and learning from the World Wide Web. *Educational Technology Research & Development*, *45*, 37–64.

Hill, C. J., Bloom, H. S., Black, A. R., & Lipsey, M. W. (2008). Empirical benchmarks for interpreting effect sizes in research. *Child Development Perspectives*, *2* (3), 172–177.

Jesenšek, M. (2011). Funkcijske in identifikacijske prvine slovenskega jezika v 20. stoletju [Functional and indentificational elements of Slovene language in 20th century]. *Studia Slavica Savariensia*, *1/2*, 161-168.

Kintsch, W., & Van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review*, *85*, 363-394.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction integration model. *Psychological Review, 95* (2), 163–182.

Koletnik, M. (2013). Leksika s pomenskega polja "gospodarska poslopja, kmečko dvorišče in kmečka opravila" v vzhodnem slovenskogoriškem podnarečju [Lexica of the semantic field "outbuildings, courtyard and rustic peasant" in the Eastern slovenskogoriški sub-dialect]. *Studia Slavica, 58* (2), 391-398.

Leu, D. J., & Kinzer, C. K. (2000). The convergence of literacy instruction with networked technologies for information and communication. *Reading Research Quarterly*, *35*, 108-127

Leu, D., & Reinking, D. (2005). *Developing Internet comprehension strategies among poor, adolescent students at risk to become dropouts*. U.S: Department of Education's Institute for Educational Science (IES).

Leu, D. J., Coiro J., Castek J., Hartmann D. K., Henry L. A., & Reinking D. (2008). New Literacies of online reading comprehension. In: Collins Block, C., Parris, S., & Afflerbach, P. (Eds.), *Comprehension instruction: Research-based best practices.* New York: Guilford Press.

Leu, D. J., Forzani, E., Burlingame, C., Kulikowich, J. M., Sedransk, N., Coiro, J., & Kennedy, C. (2013). The new literacies of online research and comprehension: Assessing and preparing students for the 21st century with Common Core State Standards. In Neuman, B. S. & Gambrell, L.B. (Eds.), *Quality reading instruction in the age of Common Core Standards* (219–236). Newark, DE: International Reading Association.

Leu, D. J., E. Forzani, E., Rhoads, C., Maykel, C., Kennedy, C., & Timbrell, N. (2014). The new literacies of online research and comprehension: Rethinking the reading achievement gap. *Reading Research Quarterly*, 0 (0), 1-23. Retrieved 30.4.2015 from: http://www.edweek.org/media/leu%20online%20reading%20study.pdf.

Lyons, D. J., Hoffman, J. L., Krajcik, J. S., & Soloway, E. (1997). *An investigation of the use of the World Wide Web for online inquiry in a science classroom*. Paper presented at the meeting of the National Association for Research in Science Teaching, Chicago, IL.

Mangen, A., Walgermo, B. R., & Bronnick, K. (2013). Reading linear texts on paper versus computer screen. *International Journal of Educational Research, 58*, 61–68.

Marsh, J. (2011). Young children's literacy practices in a virtual world: Establishing an online interaction order. *Reading Research Quarterly*, *46* (2), 101 – 118.

National Center for Education Statistics (2011a). Digest of education statistics: Table 168. Retrieved 25.05.2015 from: www.nces.ed.gov/programs/digest/d12/tables/dt12_168.asp.

National Center for Education Statistics (2011b). The Nation's Report Card: Reading 2011 (NCES 2012-457). Washington, DC: Institute of Education Sciences, U.S. Department of Education. Retrieved 25.05.2015 from: www.nces.ed.gov/nationsreportcard/pdf/main2011/2012457.pdf.

National Center for Education Statistics (2013). The Nation's Report Card: A first look: 2013 mathematics and reading (NCES 2014-451). Washington, DC: Institute of Education Sciences, U.S. Department of Education. Retrieved 25.05.2015 from: www.nces.ed.gov/nationsreportcard/ subject/publications/main2013/pdf/2014451.pdf.

OECD (2010). *Students online: Reading and using digital information.* Paris, France: OECD.

Pressley, M., & Afflerbach, P. (1995). *Verbal protocols of reading: The nature of constructively responsive reading.* Hillsdale NJ: Erlbaum.

Pulko, S., Zemljak Jontes, M. (2013). E-slovenščina - most med učiteljem in učencem [E-Slovene - a Bridge between the teacher and the student]. *Jazyk - literatura - komunikace*, *2*, 1-8.

Spiro, R. J. (2004). Principled pluralism for adaptive flexibility in teaching and learning. In Ruddell, R.B. & Unrau, N. (Eds.), *Theoretical models and processes of reading* (5th ed., 654-659). Newark, DE: International Reading Association.

Wallace, R. M., Kupperman, J., Krajcik, J., & Soloway, E. (2000). Science on the Web: Students online in a sixth-grade classroom. *Journal of the Learning Sciences*, *9*, 75-104.

Received: *June 06, 2015* Accepted: *August 03, 2015*

Metka Kordigel Aberšek	PhD., Professor, University of Maribor, Faculty of Education, Koroška 160, 2000 Maribor, Slovenia. Fax: +386 2 2518 180. E-mail: metka.kordigel@um.si
Kosta Dolenc	PhD., University of Maribor, Faculty of Natural Science and Mathematics, Koroška 160, 2000 Maribor, Slovenia. E-mail: kosta.dolenc@um.si
Andrej Flogie	M.Sc., Institute Anton Martin Slomšek, Vrbanska 30, 2000 Maribor, Slovenia. E-mail: andrej.flogie@slomskov-zavod.si
Ana Koritnik	Professor, Compulsory school Miklavž, Šolska 1, Dobrovce, 2204 Miklavž na Dravskem polju, Slovenia. E-mail: ana.koritnik75@gmail.com