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PROMOTION OF INFORMATION LITERACY ABILITIES OF SECONDARY SCHOOL LEARNERS BY PHYSICS LABS

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Abstract. *The article deals with the role of Physics lab in promoting information literacy abilities of secondary school learners. The methodological basis of research is inquiry-based learning. The article focuses on the third level of inquiry-based learning referred to Guided Inquiry. According to the Guided Inquiry, the problem and procedures of labs are predefined for students but the methods of analysis, communication and conclusions are not set and depend on the students. The research problem is formulated as a question: What are information literacy abilities of secondary schools learners and how are they determined by the guided physics experimental activity?*
Learners' information literacy abilities are analyzed on the basis of Information literacy model ACRL (The Association of College and Research Libraries). According to this model, information literacy is based on five groups of information abilities: an ability to recognize the need for information; an ability to search appropriate resources effectively and identify relevant information; an ability to evaluate information; an ability to know why information should be used in an ethical manner,and an ability to store and manage the information.
Keywords: *information literacy abilities; inquiry-based learning; Physics labs.*

Introduction

A person's ability to use Information Literacy in order to create and consolidate his or her own required knowledge is as important today. The field that deals with searching and processing information is called Information Science or Information Literacy. Information Literacy is the educated use of information in order to obtain defined knowledge (Spector-Levy, 2012). The researchers of recent information literacy frameworks emphasise the importance of flexibility, responsiveness to individual scenarios and of providing opportunities for learners to develop the capacity "to generate their own strategies for dealing with new information contexts" (Secker & Coonan, 2011). Information literacy is a multifaceted phenomenon, including learning to find information; learning to process information; learning to use information to create a product; learning to use information to build a personal knowledge base; learning to use information to advance disciplinary knowledge, learning to use information to grow as a person and to contribute to others (Diehm & Lupton, 2014).

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Information literacy abilities (ILA) are important for all individuals, from children to adult learners (Rapchak, Lewis, Motyka & Balmert, 2015). Researchers have indicated the importance of skills for retrieving information (Yang, Hwang, & Yang, 2013). Considering a lack of literature assessing such abilities in schools learners, the current article examines ILA of secondary schools learners.

There are a lot of models of ILA. In our opinion, the Association of College and Research Libraries (ACRL) provides a clearer delineation of information literacy. According to ACRL, the student will be able to demonstrate five information literacy abilities: determine the nature of information needed; access needed information efficiently and effectively; evaluate information critically and incorporate the information into the learner's knowledge and value system; use information effectively to accomplish a specific purpose; as well as understand the ethical issues of information and uses information ethically and legally (Association of College and Research Libraries, 2000).

The peculiarities of the promotion of ILA depend on form of the activity of a school subject. The learning activity at school can be theoretical or experimental. In the inquiry based Physics experimental activity, school learners need to recognize the purpose of using sources. The learners need a clearly defined question for their own project, and they need to be able to recognize the questions guiding their sources' inquiries. They must be able to evaluate the information (Refaei, Kumar & Harmony, 2015). In Physics experimental activity learners' critical thinking is assisted by eight elements: purpose, question at issue, information, interpretation and inference, concepts, assumptions, implications and consequences, as well as point of view (Pol, 2005; Gok, 2010; Gok, 2014; Paul & Elder, 2008). The discussion above highlights the **scientific problem**, which is formulated as a question: What are information literacy abilities of secondary schools learners and how are they determined by the guided Physics experimental activity?

The object of the research is information literacy abilities of secondary schools learners.

The aim of the research is to reveal the impact of guided Physics labs on information literacy abilities of secondary school learners.

The objectives of the research are as follows:

1. To investigate the information literacy abilities of secondary school learners according to the ACRL model.
2. To disclose how the guided Physics labs influence on information literacy abilities of secondary school learners.

Theoretical Background

In experimental activity, handling of information as well as information literacy itself acquire new features. N. Exner (2014) distinguishes two ways of handling information and two compliant types of collecting information: 'information synthesizers' and 'original researchers'. Information synthesizers "can make an assumption that the components of their answer exist; combine existing knowledge to answer a question" (Exner, 2014, p. 460); whereas original researchers cannot ever answer their question by searching. "Original researchers' interactions with the literature build up to a question to be asked empirically, and then their final answer comes from experimental or other non-search inquiry" (Exner, 2014, p. 460). Conducting a Physics lab, a learner performs both roles: the one of an information synthesizer and of an original researcher. These roles come out differently at inquiry based learning.

Inquiry exists as a continuum moving from more to less guidance (Brown, Abell, Demir & Schmidt, 2006; Buck, Bretz & Towns, 2008). Four levels of inquiry are distinguished in terms of the nature of their expression. The lowest level of inquiry (confirmative inquiry) corresponds to activities where learners know the possible outcomes of a labs project, and where a detailed description of activities and problems is provided. The second level of inquiry (structured inquiry) is reached in projects when learners are provided with a problem and a method for its solution. The third level (guided inquiry) is characterized by the fact that learners know the problem but have to find out how to solve it. At this level, the laboratory manual provides the problem and procedures but the methods of analysis, communication, and conclusions are for the student to design. The highest level (open inquiry) is reached when learners identify a problem, methods for its solution, and explanations for the cross-curricular phenomena themselves. The higher the level of inquiry, the more the role of an original researcher is manifested. Conducting a Physics lab at the levels of confirmative inquiry or structured inquiry, a learner performs the role of an information synthesizer, i.e. s/he combines existing knowledge to answer a question.

Conducting a Physics lab on the level of guided inquiry, the role of an original researcher is being highlighted alongside with the role of an information synthesizer. Accomplishing Physics labs based on open inquiry, a learner becomes an original researcher, as s/he has to "consult the literature to refine a question and design an experiment in order to lead to and inform empirical inquiry" (Exner, 2014, p. 461). In this article the promotion of ILA at guided inquiry level is analysed.

Methodology

The research methodology is based on constructivist theory of education, which acknowledges guided inquiry as an efficient educational technology promoting ILA and helping to apply the acquired knowledge in different situations, developing higher-level thinking abilities as well as promoting active learning processes that are based on knowledge and experience. Moreover, realist education philosophy stating that the reality of natural sciences is objective and cognisable is considered.

The method of physics labs. The educational experiment lasted one school year (2014-2015). The learners conducted eight Physics labs using guided inquiry methodology. One group of lab consisted of three learners. At the beginning of the lab, the learners were introduced to the aim and procedure of the work, but the methods of workflow and data analysis, communication, and conclusions were for the student to design. Conducting a Physics lab on the level of guided inquiry the learners becomes an original researcher and an information synthesizer. This activity influenced the ILA of learners.

The instrument of quantitative research. A questionnaire on learners' information literacy was designed for the research. According to the delineation of information literacy abilities, which is provided by The Association of College and Research Libraries (ACRL), learners have to have five information literacy abilities: determine the nature of information needed; access needed information efficiently and effectively; evaluate information critically and incorporate the information into the student's knowledge and value system; use information effectively to accomplish a specific purpose; as well as understand the ethical issues of information and use information ethically and legally. When designing the information literacy test, the methodology used for assessment of information literacy in higher education known as *Information Literacy Competency Standards for Higher Education* (Association of College and Research Libraries, 2000) was adjusted. It consists of five parts corresponding to five groups ILA by ACRL: 1) determine the nature of information[1]; 2) access information[2]; 3) evaluate information; 4) use information; 5) understand the ethical issues 50 % of questions from these standards have been chosen. They were simplified and applied for the measurement of information literacy of secondary school learners. The validity of the content of the research instrument was assured by employing the Delphi method. Two information literacy specialists, who work in Education Development Centre, assessed the

[1]The example of the question: When searching for information: a) I predict the objective, b) I set the format of the information, c) I try to gather a lot of information, d) I consult with a librarian.

[2]The example of the question: To find out whether the necessary book is in school's library: a) I search the library catalog, b) I request help of librarian, c) I ask my friends to help, d) I search in the database.

appropriateness of the designed questionnaire for the assessment of information literacy abilities of secondary school learners independently from one another. The reliability of the research instrument was assessed by calculating *Cronbach's alpha* criterion of internal compatibility of the questionnaire, which equalled to 0,829.

Sample and sampling of quantitative research. The experimental group (105 learners) was selected randomly: 55 from town, and 50 from region. Eighth-form learners of experimental group were tested using ILA questionnaire at the beginning and the end of school year.

The learners of the control group at educational experiment of one alternative were selected randomly. The sample of the control group was reliable and representative (probability cluster sample). The sample included eighth-form learners of Lithuania. The research clusters were the largest cities of Lithuania. Classes were selected on the basis of probability cluster sample and all learners of a selected class were tested.

The research sample was reliable as it involved 385 learners. The total population was 25000 eighth-form learners (EMIS – Education Management Information System). The confidence interval being 5 %, confidentiality level is 95 %. Hence, the research sample should have included 379 respondents. The probability (confidentiality level) is 95 %; therefore, the obtained data can shift only by 5 % from the population parameters (confidence interval). Eighth-form learners of the control group were tested using ILA questionnaire at the beginning and the end of school year.

Results

At the beginning of the experiment, it was decided to make sure that the learners of ILA experimental classes did not differ from the learners of ILA control group. The samples (experimental and control groups) were independent. These samples were compared on the basis of model suggested by ACRL (Table 1).

An independent-samples t-test was conducted to compare ILA in the experimental and control groups. First of all, the analysis of Levene's Test for Equality of Variances has to be conducted. This test determines if the two conditions have approximately the same or different amounts of variability between scores. If the Sig value of Levene's Test is greater than 0,05, it means that the variability in two conditions is about the same. The results of Levene's Test demonstrated that the variability in our two conditions (experimental and control groups) was about the same in four cases of ILA: determine the nature of information needed; access needed information efficiently and effectively; evaluate information critically and incorporate into knowledge system; as well as use information effectively to accomplish a specific purpose. In terms of the ability to understand the ethical issues of information, the variability in our two groups (experimental and control) is not the same and we cannot do the analysis of t-test for this ability.

The results of our research revealed that the school learners better self-evaluated the ILA abilities that were related to the original research abilities: determine the nature of information needed, access needed information efficiently and effectively, evaluate information critically and incorporate into knowledge (Table 1).

Table 1 **The Comparisons of learners ILA between experimental and control group at the beginning of educational experiment: t-test for Equality of Means**

The information literacy abilities (ACRL)	Mean[3]	Standard deviation	Levene's Test for Equality of Variances		t-test for Equality of Means		
			F	Sig.	t	df	Sig. 2
Determine the nature of information needed	38,96 35,98	18,424 16,536	0,871	0,351	1,464	476	0,144
Access needed information efficiently and effectively	36,35 33,04	16,580 10,472	4,247	0,060	1,887	476	0,060
Evaluate information critically and incorporate into knowledge	28,56 28,03	12,869 14,555	0,043	0,835	0,203	476	0,839
Use information effectively to accomplish a specific purpose	23,56 20,09	14,670 9,785	5,573	0,066	1,996	476	0,056
Understand the ethical issues of information	30,34 27,74	19,106 13,147	18,515	0,000	0,825	476	0,410

An independent-samples t-test (Table 1) shows that there is no significant difference in the scores for the abilities of experimental and control group learners: determine the nature of information needed (t = 1,464, p = 0,144); access needed information efficiently and effectively (t = 1,887, p = 0,060); evaluate information critically and incorporate it into knowledge system (t = 0,203, p = 0,839); use information effectively to accomplish a specific purpose (t = 1,996, p = 0,056).

[3]The first row represents control group whereas the second row represents experimental group.

The analysis of ILA scores of the experimental group of secondary school learners at the beginning and at the end of the educational experiment based on the guided inquiry was completed (Table 2). The guided inquiry level of experimental activity had three main peculiarities. The learners had to choose: 1) the methods of analysis; 2) the way of communication in Physics labs group; 3) the way of collaboration for finding the conclusions of Physics labs. These activities were related with the management of information. In the process of choosing the methods of analysis and formulation of conclusions, the learners had to determine the nature of information needed, access needed information efficiently and effectively, evaluate information critically and incorporate into knowledge system, use information effectively to accomplish a specific purpose, as well as understand the ethical issues of information. Information management activities had influence on the process of collaboration in the Physics labs group.

The surveys (Table 2) show that the learners much better self-evaluated the ability to determine the nature of information needed at the end of the educational experiment (at the beginning of experiment – $\bar{x}$ = 35,98 $\pm$ 16,53; at the end of experiment – $\bar{x}$ = 42,85 $\pm$ 19,48), and the ability to access needed information efficiently and effectively (at the beginning of experiment – $\bar{x}$ = 33,04 $\pm$ 10,47; at the end of experiment – $\bar{x}$ = 40,38 $\pm$ 19,20). The learners self-evaluated other information literacy abilities (evaluate information critically and incorporate into knowledge system, understand the ethical issues of information) only a little better (Table 2). To sum up, the mean scores at the end of the educational experiment were higher (except use information effectively to accomplish a specific purpose and understand the ethical issues of information) than at the beginning (Table 2).

Table 2 **Main descriptive statistics of ILA scores of experimental group learners at the beginning and at the end of the educational experiment**

Descriptive statistics	**Information literacy abilities by ACRL**				
	Determine the nature of information needed	**Access needed information efficiently and effectively**	**Evaluate information critically and incorporate into knowledge system**	**Use information effectively to accomplish a specific purpose**	**Understand the ethical issues of information**
The main descriptive statistics at the beginning of educational experiment					
Mean	35,98	33,04	28,03	20,09	27,74
Std. Deviation	16,536	10,472	14,555	9,785	13,147
The main descriptive statistics at the end of educational experiment					
Mean	42,85	40,38	32,89	17,98	26,51
Std. Deviation	19,482	19,204	15,750	9,034	13,752

The results obtained from the research (Table 2) were compared to determine the statistical difference of the self-evaluation of ILA at the beginning and at the end of the experiment of experimental group learners. The t-test for dependent samples was conducted to compare the means at the beginning of experiment and at the end of experiment (Table 3).

As seen in Table 3, it was found that the difference in scores between self-evaluation of three abilities was statistically significant: determine the nature of information needed ($t = 2{,}115$; $p = 0{,}040$); access needed information efficiently and effectively ($t = 4{,}026$; $p = 0{,}000$); evaluate information critically and incorporate into knowledge system ($t = 3{,}109$; $p = 0{,}048$). The difference in scores between evaluations ILA of other abilities (Use information effectively to accomplish a specific purpose, Understand the ethical issues of information) was not statistically significant (Table 3).

Table 3 **The comparison of experimental group learners ILA scores at the beginning and at the end of the educational experiment: the results of t-test**

Information literacy abilities (ACRL)		**t**	**df**	**Sig. (2-tailed)**
Pair 1	Determine the nature of information needed	2,115	48	0,040
Pair 2	Access needed information efficiently and effectively	4,026	48	0,000
Pair 3	Evaluate information critically and incorporate into knowledge system	2,109	48	0,048
Pair 4	Use information effectively to accomplish a specific purpose	0,265	48	0,792
Pair 5	Understand the ethical issues of information	1,010	48	0,318

At the end of the educational experiment, it was decided to compare the self-evaluation of ILA of experimental and control group learners (Table 4). The samples of experimental group and control group were independent. An independent-samples t-test was conducted to compare ILA of school learners in the experimental and control groups. First at all, the analysis of Levene's Test for Equality of Variances in the experimental and control groups has been completed (Table 4).

The results of Levene's Test showed that equality of variances was good in four cases compared: determine the nature of information needed, access needed information efficiently and effectively, evaluate information critically and incorporate into knowledge system, and use information effectively to accomplish a specific purpose. Due to a small number of questions in the group about the ethical issues of information the equality of variance was not sufficient. T-test for independent samples cannot be applied in this case.

Table 4 **Comparisons of learners' ILA of the experimental and control groups at the end of the educational experiment: t-test for Equality of Means**

Information literacy abilities (ACRL)	**Mean[4]**	**Standard deviation**	**Levene's Test for Equality of Variances**		**t-test for Equality of Means**		
			F	**Sig.**	**t**	**df**	**Sig.2**
Determine the nature of information needed	35,07 42,85	16,060 19,482	7,237	0,054	3,429	385	0,001
Access needed information efficiently and effectively	35.89 40.38	16,737 19,204	6,085	0,055	2,464	385	0,014
Evaluate information critically and incorporate into knowledge	22.04 32.89	21,191 15,750	6,578	0,051	2,337	385	0,020
Use information effectively to accomplish a purpose	18,04 17,98	14,626 9,034	7,530	0,052	0,035	385	0,972
Understand the ethical issues of information	27,08 26,51	20,467 13,752	23,642	0,000	1,759	385	0,079

The t-test results showed that after guided inquiry physics labs the self-evaluation of ILA of experimental group learners were higher in comparison to the self-evaluation of control group learners. A statistically significant difference (Table 4) was found in scores between self-evaluations of these ILA: determine the nature of information needed (t = 3,429; p = 0,001), access needed information efficiently and effectively (t = 2,464; p = 0,014), and evaluate information critically and incorporate into knowledge system (t = 2,337; p = 0,020).

Discussion

Learning to develop a process to use information typically consists of a series of generic structured steps, stages, activities, strategies or techniques (Bruce, Edwards & Lupton, 2006; Maybee, 2007; Webber & Johnston, 2013). The guided inquiry in Physics labs activity contained three main activities: the learners had to choose the methods of Physics labs and data analysis; the way of communication in Physics labs group; collaborate for finding the conclusions of Physics labs. Our research revealed that these activities influenced the self-evaluation of ILA of school learners. Choosing the methods of Physics labs required the abilities to determine the nature of information needed, and access

[4] The first row represents control group whereas the second row represents experimental group.

needed information efficiently and effectively. The learners acted like "original researchers" at this guided inquiry situation.

N. Exner (2014) suggests that "future study needs to be extended into the empirical realm to collect data on original research and its information behaviors. This is especially true in disciplines where researchers may mix reviews, concept pieces, theoretical work, and original research" (Exner, 2014, p. 465). In guided inquiry Physics labs, the learners can mix review, theoretical and original research. The data of our research showed that after Physics labs based on guided inquiry, the experimental group learners better self-evaluated the ability to determine the nature of information needed ($t = 3{,}429$; $p=0{,}001$), as well as to access needed information efficiently and effectively ($t = 2{,}464$; $p = 0{,}014$) (Table 4).

The outcomes of Physics labs require a critical evaluation of information. In the experimental activity, the critical evaluation of information is a complex process of two steps: analytic cycle with literature and analytic cycle with experimental findings (Exner, 2014). In the guided inquiry Physics labs, at the first step the learners look for the answer to the main research question (research problem) in literature (physics textbook, physics internet sites). At the second step of guided inquiry Physic labs, the learners look for the answer to main research question in empirical data through experimentation. It means that the evaluation of information in Physics labs activity has a double character. The results of our research showed that the double evaluation of information positively influenced the experimental group learners' ability to evaluate information critically and incorporate it into knowledge system ($t = 2{,}337$; $p = 0{,}020$) (Table 4).

The collaboration is an important dimension in the guided inquiry Physics labs and can help learners to locate, select, and evaluate sources (Refaei, Kumar & Harmony, 2015). The role of collaborative learning at guided inquiry Physics labs is not analysed in this article.

Conclusions

One of the important results of this study is that the school learners better self-evaluated the ILA that is related to "original research" abilities: determine the nature of information needed, access needed information efficiently and effectively, and evaluate information critically and incorporate it into knowledge. The difference between the control and experimental groups at the beginning of the educational experiment was not statistically significant.

Another result gained from this study is that guided inquiry based Physics labs have a positive effect on the self-evaluation of experimental group school learners' "original research" abilities: determine the nature of information needed, access needed information efficiently and effectively, as well as evaluate information critically and incorporate it into knowledge. The difference of self-evaluation of these abilities at the end and beginning of the educational experiment is statistically significant. It means that guided inquiry Physics labs is an effective method for the promotion of school learners' "original research" abilities.

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