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21st Century Skills of Undergraduate Students in Science and Technology: An Information Literacy Assessment

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ABSTRACT

The role of information literacy (IL) skills - one of the most necessary skills in 21st century - is recognized by the global communities as well as by Thailand as the driving tool of successfulness in the digital age. However, the study of IL in Thai context, especially in Science and Technology, is still limited.
Objective: This study aims to assess the understanding in information research process of the university students in Science and Technology disciplines in order to identify their skills level and the issues needed for skills improvement.
Method: Based on a survey undertaken by The Working Group on Library Instruction of the Subcommittee on Libraries of the Conference on Rectors and Principles of Quebec Universities (CREPUQ), an IL questionnaire was accommodated to 550 freshmen at King Mongkut's University of Technology Thonburi. The data from 442 completed questionnaires were analyzed by the basic statistics to show the response rate of the answers.
Results: The average of students' range score from the questions of information research process was between 5 to 8 points from the total score: 20 points. There were only three questions consisting of specific understanding in formulating synonym to identify a concept, using keywords, and knowing when to use a search engine, that over half of the respondents could select the best answers (56.1%, 69.5%, and 55.2%, respectively). The difference between the results from the students' self-assessment and their IL skills level is emerging. Insufficiency understanding of all areas in information research process demonstrates the students were rather low information literate.
Conclusions: The findings regarding to the learners' characteristics, level of IL competency, and comments are highlighted to the institutions to set a mandatory program of IL skills evaluation for new entry students including IL skills development courses for particular students.

Keywords
Assessment, Information literacy skills, Science and Technology, Undergraduate students

1) INTRODUCTION

In 21st century learning environment, students' achievement of information literacy (IL) becomes an essential part of their success as learners. Information literacy skills or "A set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information" (American Library Association, 1989), play an important role in academic accomplishment and lifelong learning.

Due to the importance of IL skills, THAI government has considered information competencies to Thai population at all levels and in all disciplines as stated in National Education Act of B.E. 2542 (1999) (Office of the National Education Commission, 1999). Furthermore, the term

"information literacy" has come into policy arena in 2009 in the Second ICT Master plan (2009-2013) with the vision on people at all levels of society should be smart and information literate with the knowledge and capacity to access, create, and use information in an information-literate way in order to benefit education, work, and everyday life (Pooparadai, 2010). Although IL has been included in the national polices, there are likely limited research and study on IL skills development in Thai context especially in Science and Technology disciplines which a wide variety of information sources and formats are needed for rapidly changing fields.

Science and Technology education is an important instrument in the search for sustainable development and poverty reduction. Meanwhile, educational systems are faced with the challenge of this field education that has lost relevance and not being able to adapt to current scientific and technological developments (UNESCO, 2011). As the practicing scientist and engineer need to keep up with new developments and new sources of experimental or research data, IL skills are highly important to be focused on them (Association of College & Research Libraries, 2006).

Several previous studies in IL reveal that an initiative of information competencies development was highly needed for the freshmen. However, most of the academic institutes usually presumed that their students already had a good information performance and gained IL skills automatically by themselves as they could normally operate the computer and surf the internet (Freeman & Balta, 2010; Pobert, 2009; Shanahan, 2007). Consequently, the IL skills assessment and development were rarely set as a mandatory program for the students

To evaluate IL performance, the most widely used assessments have been conducted under the standards of the Association of College and Research Libraries (ACRL). For example in Canada (Mittermeyer & Quirion, 2003), the Working Group on Library Instruction of the Subcommittee on Libraries of the Conference on Rectors and Principles of Quebec Universities (CREPUQ) has developed a questionnaire based on ACRL standards to compile data on the information research skills of undergraduate students entering Quebec Universities in 2003. The study of CREPUQ has identified the information research skills into five areas: 1-Concept Identification, 2-Search Strategy, 3-Documents Types, 4-Search Tools, 5-Use of Results, and the skills in each area became twenty variables as represented in 20 multiple-choice questions. In addition, this questionnaire has been adapted to assess the skill levels of students at other academic institutes e.g. Monash University, University of Leeds, The University of Auckland (Monash University, 2005; Harrison & Newton, 2005; Brookes & Hu, 2008; Ali et al., 2010).

With the quickly changing Science and Technology landscape requiring increasingly sophisticated information literacy skills person, evaluation of the students' IL skills will determine the important issues for academic institutes to provide more appropriate and solid approaches to strengthen their students' skills.

2) OBJECTIVES

- To investigate the IL skills level of undergraduate students in Science and Technology
- To identify the needed IL skills improvement of undergraduate students in Science and Technology

3) METHODOLOGY

3.1) Participants

The participants for this study were undergraduate students in Science and Technology. The sample was drawn from first year students of King Mongkut's University of Technology Thonburi who enrolled in GEN121-Learning and Problem Solving Skills (regular course) in the second semester of academic year 2011.

3.2) Materials

The IL questionnaire was based on a survey undertaken by CREPUQ consisting of three parts: I) General information of participant II) 20 multiple-choice questions based on skills areas (Table 2) III) Open-ended recommendation. The test items were modified to make them specifically relevant to Science and Technology students including content validity evaluated by five specialists in IL, and Science and Technology Education. The IL questionnaire was distributed to 550 freshmen in the class and 442 complements were returned.

4) RESULTS AND DISCUSSION

The results from the IL questionnaire were analyzed by the basic statistics to show the response rate of answers for each question about the participants (Part I), and the percentage of respondents who selected the best answer(s) for each question in five areas of information research skills (Part II). Furthermore, the students' comments at the end of the questionnaire were also discussed (Part III).

4.1) Part I: General Information of Participant

Table 1 shows the percentage of participant's gender and their IL training experiences. 55.9% of participants were males while 44.1% of them were females. Less than half of them had an experience in library skills training in higher education as well as in academic writing and research skills training (30.5% and 38.0% respectively).

Table 1: Information of participants

Participants' information		*F*	*%*
Gender	Male	247	55.9
	Female	195	44.1
Having experiences in			
Library skills training in higher education	Yes	135	30.5
	No	307	69.5
Academic writing and research skills training	Yes	168	38.0
	No	274	62.0

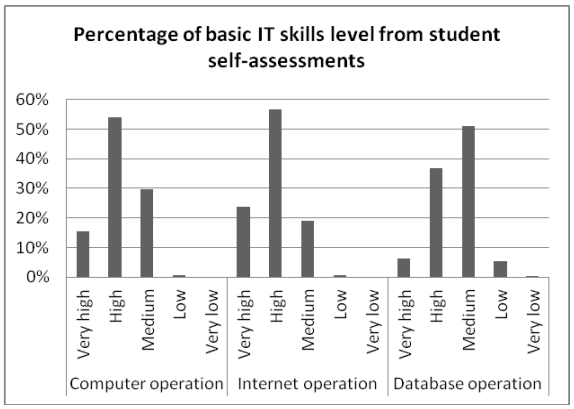

Figure 1: Results from student self-assessments

Furthermore, student self-assessments demonstrate that both skills of computer and internet operation were at high level (54.1% and 56.6% respectively) whereas the skill of database operation were at medium level (51.1%).

The results of their self-assessments (Figure 1) were compared with the results of IL test as the description is given in the following section.

4.2) Part II: Information Research Skills

Based on the survey of CREPUQ, the questionnaire was used to gather data with specific knowledge of the skills considered essential to the success of an information search in Science and Technology as stated in Table 2.

4.2.1 Area 1: Concept Identification

Significant words were used as variables for all questions in Area 1 to examine how the respondents determine the concepts to be used when defining a search strategy.

Table 2: Summary of results by areas of information research process

Information research process	*Specific knowledge of the question*	*No.*	*% of correct answers*
Area 1	Using appropriate terms to identify the main concepts	4	47.7
Concept	Distinguishing between significant and non-significant words	8	31.4
identification	Formulating synonym to identify a concept	13	**56.1***
Area 2	Using keywords	2	**69.5***
Search strategy	Using Boolean operator "OR"	9	39.4
	Using appropriate search indexes	11	29.6
	Using a thesaurus to get the preferred vocabulary for a particular database	12	30.3
	Using Boolean operator "AND"	16	45.5
Area 3	Knowing when to cite an encyclopedia	3	18.8
Documents types	Knowing when to cite a scholarly journal	15	49.5
	Knowing the criteria of a scholarly journal	20	11.3
Area 4	Knowing when to use a database	1	9.7
Search tools	Knowing when to use a search engine	6	**55.2***
	Knowing how to find information in a library catalogue	7	13.1
	Knowing the characteristics of meta-search engines	14	5.2
	Knowing what information can be found in a library catalogue	17	12.7
Area 5	Recognizing the type of document in a bibliographic reference	5	11.8
Use of results	Knowing what a bibliography is	10	40.3
	Knowing the criteria used in evaluating the quality of a website	18	9.7
	Knowing when to include a reference to avoid plagiarism	19	14.7

Note: *A rate of above 50% of participant who selected the correct answers

For Question 4, 47.7% of the respondents could identify the main concepts with appropriate keywords in the topic *"Using alternative energy in automobile manufacturing plants in Asia"* while others selected the answers with non-significant words. To distinguish between these keywords in the topic *"The effects of climate change due to global warming in Thailand"* in Question 8, about a third of respondents (31.4%) answered correctly while 51.1% of them selected the answers by including restrictive terms such as *"effects"* which reduces the number of search results obtained. For Question 13, over half of the respondents (56.1%) seemed to be able to recognize words with similar meaning in the topic *"Measures currently used across the country to decrease the damage to natural environment"*. The best answer of this question consisted of significant words including the word *"protective measures"* which were used as synonym of the word *"measures to decrease damage"*, and the word *"Thailand"* which implied from the original term *"country"*.

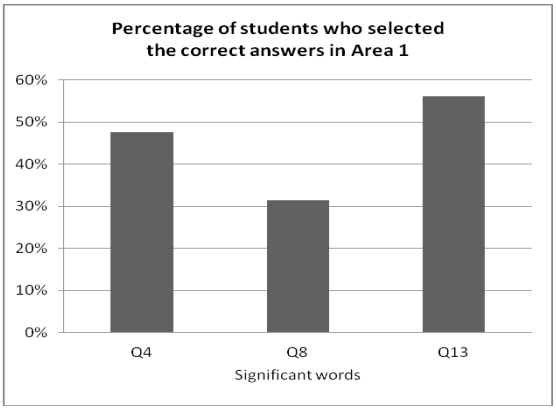

Figure 2: Result of Concept Identification

Figure 2 shows the results from three questions in Area 1. Even over half of the students could answer correctly in Question 13, the synopsis of their comprehension in concept identification was still inadequately.

4.2.2 Area 2: Search Strategy

Search strategy was focused in Area 2, comprising five variables: translation into keywords, Boolean operator "OR", search indexes, controlled vocabulary, and Boolean operator "AND". For Question 2, 69.5% of respondents appeared to recognize the problem of using term *"small-sized technology"*, which did not correspond with *"nanotechnology"* employed and preferred by the OPAC system. To get more search results by using Boolean operator in Question 9, over a third of the respondents (39.4%) selected "OR" operator which is the best suite for the synonym of *"car"* like *"vehicle"* and *"automobile"*. For Question 11, the students were asked how they would do the search to find all the documents about *"Albert Einstein"* in the library catalog. The results of this question show that less than a third of the respondents (29.6%) could use the search indexes correctly while most of them (60.1%) failed to differentiate between an author, a title, and the subject of search. Mastery in the concept of controlled vocabulary is a part to develop an effective search strategy. However, there were almost 70% of the respondents failed to select a thesaurus as a tool in searching for preferred terms for a specialized database in Question 12. The search strategy with Boolean operator "AND" were used to find the documents containing all specified search terms in Question 16. The results indicate that less than half of the respondents (45.5%) were familiar with the "AND" operator.

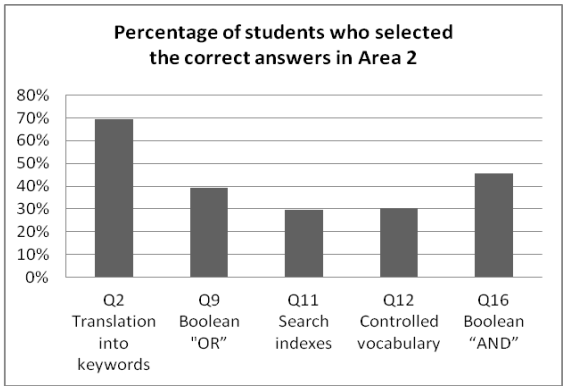

Figure 3: Result of Search Strategy

Figure 3 shows the results from five questions in Area 2. Most respondents seemed to have a great awareness in use of keywords. On the contrary, over half of them lacked the strategy to perform searching efficiently by using the inappropriate Boolean operators, missing the point of search index in an OPAC system, and unawareness of controlled vocabulary tools like a thesaurus.

4.2.3 Area 3: Document Types

Encyclopedias, scholarly journals, and criteria of scholarly journals were used as variables for three questions in Area 3. The results from Question 3 demonstrate that only 18.8% of the respondents know when they should consult an encyclopedia. To verify whether the students understand the characteristics of various types of documents, the respondents were asked which document types they could find the most recent and reliable information about "solar cell" in Questions 15. Almost half of the respondents (49.5%) knew the scholarly journals containing more up-to-date and more authentic information than other types of documents. Multiple answers were allowed in Question 20 in

order to be selected for the best describe(s) of a scholarly journal. The results represent that only 11.3% of respondents could select all the correct characteristics of the scholarly journal.

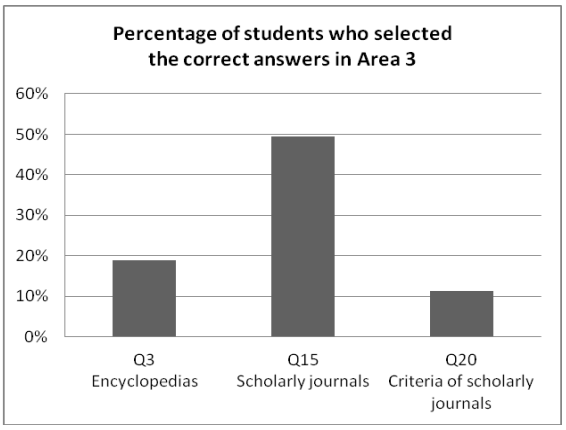

Figure 4: Result of Document Types

Figure 4 shows the results from three questions in Area 3. Most of the respondents lacked the knowledge in identifying the criteria of different document types. Especially the scholarly journal, least of the respondents comprehended this essential source of information containing theoretical discussions or research results for a specialized public. The students in Science and Technology are emphasized to study scientific information from the scholarly journals influencing the new developments or experiments.

4.2.4 Area 4: Search Tools

Databases, search engines, library catalogues, and meta-search engines were variables used for five questions in Area 4, to evaluate the selection of a search strategy according to the search tools available. For Question 1, only 9.7% of the respondents knew that a database is the most efficient search tool for finding journal articles about *"innovation in energy-efficient buildings"* while 74% of them chose Google, which can provide links to some journals but requires more complex procedures to get the articles. Question 6 was developed to verify understanding of the students in search engines like Google. Over half of the respondents (55.2%) recognized that search engines are not appropriate tools for finding documents held by the library. Both Question 7 and 17 were used to exam the knowledge of library catalogue, the search tool enabling library users to find documents available at the university. To access a journal article via the OPAC system, there were only 14% of the respondents selected the search indexed by author which is the most appropriate answer in shortening the search procedures for Question 7. Multiple answers were allowed in Question 17 in order to be selected as the items could be found in the library catalogue. The results represent that only 12.7% of respondents could identify all the correct items. For Question 14, a large number of the students were unlikely familiar with the meta-search engine as 56.8% of respondents answered that they did not know the appropriate answers for this questions.

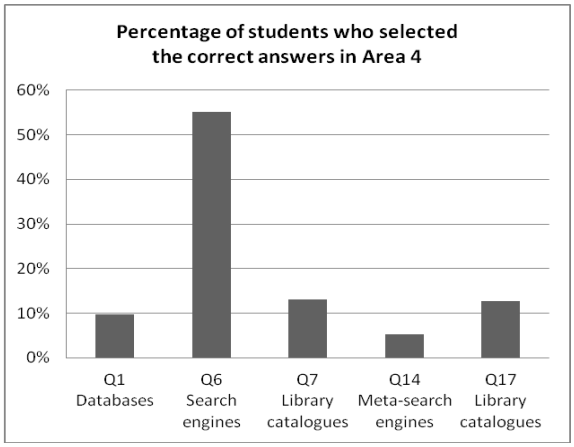

Figure 5: Result of Search Tools

Figure 5 shows the results from five questions in Area 4. Even most students seemed familiar with Google, they were aware neither the types nor the limitations of the search engines. Furthermore, the results demonstrate that students seriously lacked comprehension in the databases contrasting with the medium level from the self-assessment in their skills of database operation displayed in Figure 1. The students also had insufficient skills for the

library catalogue use. Only a few of them knew clearly how to use search index and the kind of information can be found in the library catalogue.

4.2.5 Area 5: Use of Results

Reading citations, bibliographies, evaluation of information, and ethical use of information were used as variables for four questions in Area 5. The results from Question 5 represents that majority of the respondents (88.2%) were neither able to interpret a bibliographic reference nor recognize the corresponding document type. For Question 10, over one-third of the respondents (40.3%) knew that they could use bibliographies to find relevant documents. Although the internet is increasingly used as the information source, only 9.7% of respondents knew the criteria to evaluate the quality of an internet site in Question 18. Only a few respondents (14.7%) knew when to include a reference to an article they cite in Question 19.

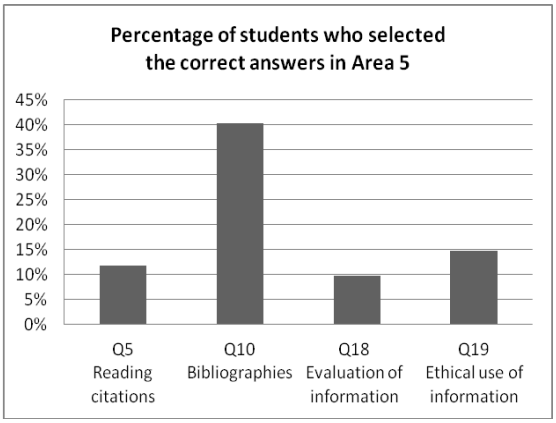

Figure 6: Result of Use of Results

Figure 6 shows the results from four questions in Area 5. Almost 90% of the respondents demonstrated that they lacked comprehension in the internet sources evaluation contrasting with the high level from the self-assessment in their skills of internet operation displayed in Figure 1. To commit plagiarism without realizing may be a big problem of the students. They need to gain the knowledge of citation as an ethical requirement and the ability to identify and locate the works.

The summary results indicate the percentage of respondents who scored from each question in five areas with the total score: 20 points. The average of students' range score was between 5 to 8 points. For that matter, there were only three questions consisting of specific understanding in formulating synonym to identify a concept, using keywords, and knowing when to use a search engine, that over half of the respondents could select the best answers (56.1%, 69.5%, and 55.2%, respectively). In contrast with the results from the students' self assessment, this insufficiency understanding of all areas in information research process demonstrates the students were rather low information literate.

4.3) Part III: Open-ended Comments

The following comments from the respondents reveal that some students recognized the complication of the information research process. They needed madatory courses or regular programs to influence their abilities in information research while some of them thought the IL skills are not necsessary. Addtionally, the students were rather familiar with internet search engines like Google than databases because of the accessibility, even the search engines are not always appropiate for all kinds of information.

-*"It would be great if our university set 'How to operate each available database in library' as a madatory program"*
-*"Any particular courses of these skills in our university?"*
-*"Google is the most easily used search tool, it's quite boring to find information from such complex databases"*
-*"Google only!"*
-*"The questions in this assessment are quite hard for me as I have no knowledge in these skills"*
-*"I think I am not concerned with these skills"*

-*"Because of limited knowledge in information literacy, most of people cannot use information effectively"*

5) CONCLUSIONS

The summary results regarding to the students' characteristic, IL skills level and perspectives, reveal their limited information comprehensions. The low information literate students represented by the weak results from five areas of information research process is indicative of a serious problem that requires the academic institutes' attention to strengthen their students' information competency with the initiative approaches especially a mandatory program of IL skills evaluation for new entry students and IL skills development courses for particular students in Science and Technology.

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