

Information literacy and self-regulation in the context of the creative thinking of prospective engineers

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ABSTRACT: The objective of this study was to investigate the information literacy level and self-regulation of prospective engineers. The authors investigated the issues through a descriptive qualitative method. The findings showed that the information literacy of engineering students is strongly correlated with critical thinking ability. Nevertheless, only a weak positive correlation between self-regulation and information literacy of engineering students was revealed. The later part of the article is focused on the Empowering Eight (E8) model of information literacy used as a benchmark to measure information literacy of prospective engineers. To enhance students' information literacy and self-regulation, it is pivotal to enforce creative critical thinking learning and assessment as learning within the engineering student learning process.

INTRODUCTION

Reading - which is among the basic linguistic skills - has a significant position in intellectual life. This is because perception, meaning construction, information retrieval and the reuse of the acquired information in written communication is heavily dependent upon reading. Though the question of whether physical or cognitive processes are more effective in reading has been answered differently by researchers, the consensus on the nature of this activity is that it is a rather complicated process. To explain this complicated process, the concept of critical reading recently has been put forward as a model in education.

Critical reading can be regarded as an attempt at *re-reading*, which requires handling many concepts affecting lives directly or indirectly from a wider perspective. The aim of this study was to investigate the effect of a science and technology lesson, arranged within the context of critical reading, on students' academic achievement, critical thinking and critical reading skills. Reading is an action that adds meaning to, and shapes lives, as well as providing one with different points of view [1][2]. Prospective engineers have a need to acquire 21st Century skills, which include critical thinking ability, creativity, collaborative skills and communication skills. Critical thinking in the context of information literacy encompasses the ability to analyse, interpret, predict and evaluate information obtained.

During the present age of information, every individual has a need for diverse and distinctive information, both as knowledge enhancement, and as a means of solving a problem. The development of information currently is accompanied by the advancement of information technology which offers an accessible channel of information that meets demand. The accessible information obtained by people nowadays has several impacts. One of the impacts that command attention is an information explosion. Information explosion can result in ambiguous information widely spread to people. It means that the validity of information obtained by people is questionable.

In dealing with this phenomenon, the individual requires a particular ability to filter various sources and types of information tailored to the needs of the individual. The ability that must be mastered by individuals is information literacy skills. Information literacy is also interpreted as being knowledgeable in information, which includes the awareness of the individual regarding the information, which they need to identify; effectively and efficiently access; evaluate and incorporate the information into knowledge; and communicate the information. Information literacy is seen as highly essential, particularly for prospective engineers.

In this article, the authors discuss further:

- information literacy comprehension and self-regulation of prospective engineers;
- correlation between information literacy comprehension of prospective engineers and creative critical thinking;
- correlation between information literacy comprehension and self-regulation of prospective engineers.

Earlier research studies focused on the examination and observation of information literacy skills of engineering students. For example, Baro and Fyneman conducted a study regarding information literacy among undergraduate students [3]. The findings revealed that gender plays a role in the awareness of information literacy. Alkehzzi and Hendl discovered that information literacy played an important role in students' perspective when utilising academic and educational resources to support their study [4]. Detlor et al [5] and Mulla [6] revealed information literacy in the context of learning encouragement. However, it appears that no further studies explain its correlation with any element of educational context. Additionally, studies on information literacy and its correlation with the elements of learning context, such as critical thinking on engineering students are still limited. Therefore, the authors were intrigued to look deeper on the issues.

METHOD

This study employed a qualitative approach to reveal the issues. It included 29 Bachelor degree students of the Engineering Department at the State University of Malang who had completed at least four semesters at the University for collecting the data by means of questionnaire. Empowering Eight model, also known as Empowering-8 IL, developed by IFLA-ALP was employed as the instrument in collecting the research data [7]. The subjects provided answers to the questionnaires by using the Likert scale. Then, the data obtained was analysed and processed by employing statistical processing to obtain the correlation. The obtained analysis was then descriptively explained.

RESULTS

After obtaining a data set through the distribution of questionnaires, the data were analysed by means of statistical processing to reveal the correlation result. Table 1 below presents the detailed results of the correlations among information literacy, self-regulation and critical thinking.

Table 1: Correlation results.

		Information literacy	Self-regulation	Critical thinking
Information literacy	Pearson correlation	1	0.306	0.039
	Sig. (2-tailed)		0.106	0.839
	N	29	29	29
Self-regulation	Pearson correlation	0.306	1	-0.204
	Sig. (2-tailed)	0.106		0.288
	N	29	29	29
Critical thinking	Pearson correlation	0.039	-0.204	1
	Sig. (2-tailed)	0.839	0.288	
	N	29	29	29

According to Table 1 above, it shows that the correlation between information literacy and self-regulation is 0.106. When the correlation value of the variables is between 0 and 0.3, it indicates a weak positive correlation. Thus, information literacy has weak correlation with self-regulation. Meanwhile, the correlation value between information literacy and critical thinking is 0.839. When the correlation value of the variables is between 0.7 and 1.0, it indicates a strong positive correlation. Thus, information literacy has strong correlation with critical thinking.

INFORMATION LITERACY AND CREATIVE CRITICAL THINKING

According to the analysis, a correlation was confirmed between information literacy comprehension and critical thinking ability. In this research the Empowering Eight model (E8) of information literacy was applied as a benchmark, to measure the information literacy comprehension of prospective engineers.

Based on the E8 model, there are eight information literacy indicators, which include the ability to:

1. identify;
2. explore and investigate;
3. choose or select;
4. organise or administer;
5. generate;
6. present;
7. examine;
8. implement.

Each ability has several sub-indicators. The authors have described the several questions that arise from each indicator. The following explanation covers the findings and analysis of the Empowering Eight model.

Ability to Identify

The process of *identifying* could be considered adequate when the individual is capable of identifying:

- a problem or issue which requires a solution;
- a final scheme of solution;
- keyword(s) and a designing strategy to inspect and explore required information, including the source of information to be used later on.

The findings of this research are in accordance with the standard presented by the Association of Colleges and Research Libraries (ACRL) focusing on college students' needs in the context of higher education (indicator 1). A college student is considered to fulfil information literacy comprehension when they are able to determine information character and scope; within the component of defining information need.

In the process of defining information need, a college student will determine the topic and subject to be analysed before browsing and searching the related information. After knowing the topic and subject of the issue, a college student will then determine the appropriate and relevant strategy they need to employ during information exploration. Strategies to search and explore information which can be applied by college students are:

- Searching for information by using important keywords, such as title, author(s) or subject. This strategy enables college students to search for information through one word, phrase or a combination of word and phrase.
- Boolean strategy by utilising operators in obtaining the information. This strategy enables college students to search for information by using the AND operator (when an individual aims at searching an information source, which consists of two or more words at one time; for instance, Indonesia AND export), the OR operator (when an individual aims at searching an information source which consists of one word from the terms required).

Associated with critical thinking skills, the ability to identify takes a role as the basis of the ability to interpret and integrate information [8]. The right information strategy planning will produce the right and relevant information in accordance with the topic and subject matter being sought. To get a clearer picture of identifying problems that will be used as working examples, a situation analysis is performed and a problem is formulated. Information analysis is conducted through information gathering (looking for information and seeing what others have said or know about a topic) and brainstorming (a technique used to explore, sharpen and develop ideas, relationships between ideas).

Ability to Explore and Investigate

The ability to explore is that of determining the sources that match the chosen topic. In determining the sources of information and determining information, students need the ability to think critically. The findings of this research, which reveal the correlation between information literacy comprehension and students' critical thinking ability, are in line with Latuputty's research [9]. She explains that during the exploration or investigation stage, an individual will begin to explore the information they need. Furthermore, if detailed information is needed, they will conduct an interview or apply any collecting-information method.

A student is considered to be literate if they have carried out the exploration stage in the research process or in working on a task. One of the thinking skills related to information literacy comprehension is collecting resources. It is an individual's ability to process various sources required in both printed and non-printed forms, on-line and computerised; as well as expert interviewing; requesting suitable government documents; and consulting with librarians and other experts for suggestions on additional resources needed. The process of gathering information sources that are in accordance with the topic will make it easier for students in the stage of determining information that corresponds to the topic.

When a student performs exploration on information, they check and investigate information based on the truth, authorship authority and information novelty level before they determine the appropriate information. According to Facione, the ability to explore is closely related to the ability to interpret [8]. The ability to interpret enables an individual to understand and reveal a certain meaning or meaning in general from the various situations, data and events. It consists of three sub-skills, which are:

- categorising;
- explaining meaning;
- classifying.

To identify the required elements to draw or generate a logical conclusion, generating predictions and hypotheses, considering relevant information, an individual has a need to acquire the ability to infer. Three sub-skills of the ability to infer are:

- challenging the proof;
- providing an alternative;
- drawing a conclusion.

Ability to Determine or Select

This ability empowers an individual through performing the selection, choosing and recording the relevant information, and it is continued by creating a note or designing the visual arrangement, such as a chart, graphic illustration and a schematic. According to Facione, when an individual performs the ability to determine or select, it is highly related with the ability to analyse [8]. The ability to analyse enables the individual to perform identification and generate correlation of statements, questions, concepts or descriptions to express belief, judgment, reason or opinion. When an individual performs analysis, they deal with:

- selecting opinion;
- identifying an argument;
- analysing an argument.

Ability to Organise and Administer

Someone is considered to have fulfilled the organisation of information literacy when the individual is able to choose the information that has been collected from the selection process and arrange the selected information in a logical arrangement. It is necessary to evaluate the information process and evaluate information sources critically after carrying out the information selection stage. In the evaluation process, there are several activities that can be carried out by students, including summarising the main ideas that can be quoted from the information gathered, issuing and using initial criteria to evaluate information and sources, and gathering key ideas to build new concepts. It is associated with the stages of critical thinking. According to Facione, these skills are related to structuring skills, sorting uniquely to construct an idea [8].

Ability to Create

Someone is considered to have achieved the creative ability of information literacy when they are able to create a product in response to problems through information that has been obtained. The step taken after the information selection and evaluation process is the stage of communicating information; namely, sharing information by providing benefits to others from research questions, in the form of reports, posters, graphics or appropriate articles. In creating a product or report, students will compare new knowledge with prior knowledge to determine its additional value, contradiction or other unique characteristics of information. At the stage of creating, students will create a product based on information that has been obtained, into written forms, such as reports and journals. At this stage students will compare new knowledge with previous or prior knowledge to determine additional value, contradictions or other unique characteristics of information which will then be conveyed into their products.

Ability to Present

When performing the ability to present, an individual will present what they have obtained in any form of presentation. The findings obtained in this present research are in line with the discoveries of Harsiati [10]. It indicates that college students' ability to retain information is correlated with the ability to present the obtained information.

Ability to Assess and Implement

The ability to assess is an important basis for the ability to think critically. The ability to reflect also is related to the ability to think critically. The stage of application is the information literacy ability, which can be seen from the ability to reformulate the work results by considering input. An individual's ability to assess and apply deals with information to accomplish certain goals, use new and prior information for planning and creating results, and revise the development process for more effective and better results. This ability is in line with aspects of the critical thinking ability, which include the ability to assess and reflect on what is produced.

SELF-REGULATION AND CRITICAL THINKING ABILITY

Self-regulation and Assessment as Learning

Regrettably, this present research confirms only a weak positive correlation between students' self-regulation and information literacy comprehension. The results of this research are in line with the opinion of Zimmerman, stating that learners can be considered to have self-regulation in learning when in the learning process the learner involves the use of specific strategies to achieve their academic goals [11]. Learners have high self-regulation when they have an active role in mobilising metacognitive processes, motivations and behaviour while learning. Learners who have self-regulation in learning will be able to direct themselves, make plans, organise material, instruct themselves and evaluate themselves in the learning process. From this opinion, it can be seen that self-regulation is closely related to the aspects of emotions, motivation and behaviour.

On the other hand, information literacy comprehension is closely related to thinking ability of the individual. In other words, information literacy comprehension predominantly deals with the aspect of cognition. Meanwhile, self-regulation predominantly deals with affective aspects. Therefore, it is understandable when this research affirms that

there is only a weak correlation between information literacy comprehension and self-regulation among prospective engineers.

IMPROVING INFORMATION LITERACY COMPREHENSION AND CREATIVE CRITICAL THINKING

From the results of research about prospective engineers, it was found that information literacy comprehension correlates with creative critical thinking. Therefore, appropriate learning and assessment are needed to improve the ability of creative critical thinking. Creative thinking is manifested in four forms; namely, sensitivity, originality, flexibility and fluency. Regarding these in the thought process that generates an idea (creative), it is deemed necessary to have further action to fix and organise or regulate and what in detail has been produced. This needs to be performed, so that the individual does not lose momentum in the learning, particularly before the good ideas that arise are forgotten. This regular and detailed organisation enables the opportunity for prospective engineers to be able to repeat or read at any time and review what they produce.

In relation to learning that can improve critical-creative thinking skills, there are several studies that affirm the improvement of creative thinking ability. Kirmizi and Kasap reveal a study of the influence of creative reading and creative writing to improve creative-critical thinking. Learning that focuses on creative reading can enhance creative thinking [12]. In line with the aforementioned argument, Facione has produced a taxonomy of critical thinking learning with an emphasis on developing skills [8]:

- interpreting;
- analysing;
- influencing;
- evaluating;
- explaining;
- regulating themselves.

The Facione taxonomy was developed based on the agreement of experts and the six levels of thinking were synthesised from the best dimensions of critical thinking. The six levels in the Facione taxonomy presented above are discussed in more detail below.

The skill of interpreting empowers an individual to understand and express the broad meanings or context of various situations, data and events. This interpreting skill has three sub-skills; namely,

- categorising,
- explaining meaning;
- classifying.

Analytical skill enables the individual to identify and correlate statements, questions, concepts or descriptions to express or expose beliefs, judgments, reasons or descriptions to express beliefs, judgments or opinions. Analysis skill consists of sub-skills:

- ideas assessment;
- arguments identification;
- arguments analysis.

Within influencing skill, the individual is empowered to be able to identify the elements needed to draw reasonable conclusions, make predictions and hypotheses, as well as consider relevant information. Inferring skill consists of three sub-skills, they are:

- challenging the evidence;
- proposing alternatives;
- making conclusions.

The skill to evaluate belongs to another skill that performs an assessment on the credibility that entails within certain statements based on perceptions, situations, beliefs or opinions. Within the skill of evaluating, an individual will deal with two sub-skills, and these are:

- assessing claims;
- assessing arguments.

But explanatory skill enforces prospective engineers to state, argue and explain information, data, evidence-based ideas, concepts, methods and criteria. This skill consists of three sub-skills:

- declaring results;
- justifying procedures;
- presenting arguments.

Self-regulating skill is for monitoring cognitive activities through self-analysis and evaluation. Within this skill, the individual deals with two sub-skills:

- self-assessment;
- self-correction.

Findik and Bahadir have developed their own interpretation of taxonomic thinking skills to compile problem-based problem solving; namely,

- exploring and understanding;
- representing and formulating;
- designing and implementing;
- monitoring and reflection.

The taxonomy of exploring and understanding involves the ability to explore problems by observing, interacting, tracing information, finding constraints, and showing understanding and findings. The taxonomy of representing and formulating involves the ability to use graphs, symbols or words to describe problems, form hypotheses or interim conclusions that are related to factors relevant to the problem or situation. The taxonomy of designing and implementing involves the ability to find a draft strategy for solving problems and implementing it. This includes clarifying objectives and designing sub-goals. The taxonomy of monitoring and reflecting involves the ability to monitor progress, reactions and feedback, as well as reflect on solutions that are suitable for the chosen problem or strategy [1][13].

Creative thinking is a thinking ability that begins from being sensitive to the *challenging* problem that is being faced. Furthermore, there are elements of originality of ideas that arise in an individual's mind related to what is identified. The results from creative thinking are actually new for the individual concerned and are something different. Creative thinking also appears in the form of the ability to find new relationships and to look at things from different perspectives.

Akin et al reveal the results of experimental research regarding critical thinking skills. The experts found that critical thinking learning through scientific texts influences academic achievement, critical thinking ability and critical reading ability [14].

CONCLUSIONS

Based on the results and discussions that have been presented it can be concluded that the information literacy comprehension of prospective engineers is sufficient. The ability to self-regulate among prospective engineers belongs to the low category. From the results of the analysis, it was found that there was a correlation between the level of information literacy comprehension and the ability to think in a creatively critical way. The results of the study show that there is only a weak positive correlation between the ability to self-regulate with information literacy comprehension among prospective engineers.

In an effort to improve information literacy comprehension and the ability to self-regulate, it is suggested that learning includes critical reading activities and creative reading. In addition, it is recommended that the implementation of assessment as learning is one approach to improve self-regulating ability.

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