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Does IL education have an impact on undergraduate engineering students' research skills?

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Abstract

This paper presents the first results of testing a model of studying the change in undergraduate students' research skills after receiving information literacy (IL) instruction. The model is tested with a group of Master's level engineering students attending a construction materials' seminar. The IL instruction consists of presenting the basics of information searching in general, the basics of bibliometrics, and searching guidelines of the most important databases in the field of mechanical engineering and material science. After the lecture, the students attend an instructed hands-on information retrieval training session. In order to enable information retrieval from the most important non-English sources, the students attend tailored French or German language education according to their choice.

To determine whether information literacy education can be used as a means of improving the technological university undergraduate students' research skills, special attention is paid on the students' ability to describe their research problems and to formulate the research questions in their final papers. Moreover, the scientific value and versatility of the source literature are observed. The research methodology for evaluating the model is based on classical qualitative analysis.

Keywords: Information literacy; Education; Bibliometrics; Materials science

1. Introduction

The higher education engineering students need both research skills and knowledge of how to find high quality scientific information sources for their assignments at all levels of their curriculum. To learn these skills, the students, in most cases, attend information literacy (IL) education arranged either by the university library or the library and faculty in cooperation. There is plenty of research done on the effects of IL education on students' searching skills. Some of these studies are presented by Callan, Mitchell-Kamalie, and Stock (Callan, Peacock, Poirier, & Tweedale, 2001; Mitchell-Kamalie, 2011; Stock, 2008) who, for example, describe ways in which information literacy has been integrated into the course curriculum. Robinson and Schlegl examined student reference lists to study the efficacy of IL instruction in relation to the quality of citations and student grades (Robinson & Schlegl, 2004). Moreover, Floyd, Colvin,

and Bodur used citation analysis to study the impact of IL instruction on the use of scholarly resources and the quality of student research (Floyd, Colvin, & Bodur, 2008). There is even a pilot study on the effect of IL education on e.g. the students' ability to define their research questions in a multidisciplinary university (Bury, 2011).

However, the influence of IL education on the essential research skills has not been considered enough. Ganley, Gilbert and Rosario conducted a pilot study of the effects IL education on students' research skills in an American university. They compared first-year students' ability to find and use information with that of fourth-year students. (Ganley, Gilbert, & Rosario, 2013.) Some of their results can be applied to this case, but the question of the effect of tailored IL education on the students' research skills in a technological university is yet to be studied.

2. Research frame and practical arrangements

In this pilot research, two small groups of undergraduate engineering students were studied to test the suitability of the research method to examine the impact of IL education on students' research skills. The studied student groups consisted of 10 Master's level Finnish students attending the *Construction materials seminar* and 14 international students on the course *Research methods and methodology*.

As part of their seminar curriculum, the Construction materials seminar students attended tailored French or German language education according to their choice in order to be able to retrieve information from the most important non-English sources. The students wrote literature review seminar papers. The Research methods group prepared research plans on given topics. The change in students' information seeking methods was studied in both groups but the analysis of information use and the bibliometric analysis were done only in the Construction materials group since the other group did not write a complete paper but only a research plan.

Both classes were divided into a research group and a comparison group. The Construction materials research group received a two-hour IL lecture and a two-hour instructed hands-on information searching instruction. The Research methods research group attended a two-hour combined lecture and hands-on training.

To determine the starting level of the students' information searching skills and, to some level, also their bibliometric understanding, both the research groups and the comparison groups answered a questionnaire before IL education. The questionnaire consisted of the following questions:

1. What is your research problem?
2. How and where do you plan to search information about your topic?
3. What search words do you plan to use and how do you perform the search?
4. What do you expect to get as result?
5. How would you rate your ability to search information?

The research groups then attended IL education. The Construction materials students' lecture covered the theory of information searching, introduction to the most important databases in their field of science, and the basics on bibliometrics. The content of the lecture was:

- Characteristics of different information sources
- Selecting information sources for searching

- Selecting search words
- Combining search words
- How to use the Nelli portal
- Demonstration of searching information in ProQuest, Science Direct, Scopus
- Analyzing tool of Scopus
- Impact factors in Journal Citation Reports (JCR)

ProQuest was selected as an example of a reference database source. Within ProQuest, there are several individual databases which provide the user with information on materials science. Moreover, it allows the user to find search words in the Thesaurus and helps students to learn about the hierarchy of concepts. Science Direct is an excellent example of a source of high quality scientific information. The search features in Science Direct are diverse allowing students to learn, for example, the power of proximity operators. Scopus was presented as an information source as well as a tool for analyzing search results. Both Scopus and JCR were used to give an idea of the scientific value of retrieved information.

After the lecture the research group students answered another questionnaire with the following questions:

1. How and where do you now plan to search information about your topic?
2. What search words do you plan to use and how do you perform the search?
3. What do you expect to get as result?
4. How would you now rate your ability to search information?

As mentioned before, the Research methods and methodology group had a joint lecture and hands-on training session while the Construction materials group had a separate hands-on training a week after the lecture. In a computer lab, the students were instructed by a professional information specialist to search information on their topic. After the hands-on session they were asked the following questions:

1. How and where did you search information about your topic?
2. What search words did you use and how did you develop your search?
3. What did you get as result? What kind of sources did you find?
4. Do the results meet your information needs?
5. How would you now rate your ability to search information?

Qualitative analysis of the answers in the questionnaires was done first to find different aspects, which then were grouped and used for quantitative analysis. In addition to examining the questionnaires, the Construction materials students' seminar papers were studied to analyze the students' way of using information and to determine the scientific level of the cited documents. The faculty teacher also examined the seminar papers focusing on the differences in the quality of the papers produced by the research group and the comparison group students.

3. Research results

The aim of this paper is to present a pilot study of the impact of information literacy education on undergraduate engineering students' searching behavior, knowledge of information sources, ability to find high quality scientific information, and to use the information in an appropriate way in their assignments.

The pilot group consisted of 10 students attending the Construction materials seminar. The results were verified by studying the changes in the searching behavior of a group of 14 students in the Research methods and methodology course. An interesting detail was that in the course module feedback students expressed their excitement by valuing the course as 'excellent'. This reflects the students' high motivation to information searching and to the writing process.

3.1. Changes in information searching

Major changes can be seen in the information searching behavior of the students. According to the first questionnaire, the students planned to use single, keyword-type words or word chains. They could not specify a search plan although a foggy idea of combining words could be seen in some answers. After the lecture, students presented search strategies which included clear search phrases with Boolean operators as well as using alternative search words, truncation, and parentheses. They could also use both the term in full and its abbreviation correctly in a search statement. After hands-on training, more advanced use of Boolean operators and truncation could be seen in their answers. Moreover, they had used quotation marks to indicate the use of phrases. Using the Scopus database had been required by their professor. Therefore it was not surprising to see the use of the 'Analyze results' tool in Scopus. However, discussing the meaning of impact factors, limiting the search term to title or keywords, limiting the search by document type, and narrowing the search down according to viewpoint were unexpected findings. Table 1 shows the changes in students' searching behavior.

Table 1. Changes in students' searching behavior.

Before IL lecture	After IL lecture	After hands-on training
Basic form single words, keyword-type words.	Truncated words	Truncated words
Word chains	Alternative search words combined with OR. Terms in full and their abbreviations combined with OR.	Quotation marks indicating phrases.
No search strategy	Search strategies using Boolean operators.	Limiting the search term to title or keywords. Limiting by document type. Narrowing the search by viewpoint.
Foggy idea of combining words	Boolean operators	Advanced use of Boolean operators.
	Parentheses	
		Attention to impact factors
		Analyzing results, Scopus.
		Using advanced search.

An interesting finding was, that the development in searching behavior in both classes was very similar. In general, the answers did not differ. However, after the education only Construction materials students mentioned impact factors as important data when determining which journals to search for information. Students in Research methods and methodology, on the other hand, named different ways of limiting the search to get better results after they had attended the education session. These matters did not occur in the Construction materials seminar students' answers. All students expressed more realistic expectations of the search results and greater confidence in their searching skills as the process went on.

3.2. Changes in the use of information sources

Before the lecture, Construction materials seminar students mentioned a number of databases where they planned to search information. Six sources appeared more often than others, namely Google scholar, Nelli ("school databases") portal, Scopus, Library (Wilma catalog), Internet (Google), and Science Direct (Elsevier). Arto database (Finnish article references), Periodicals, Producer datasheets, Professors/teachers, ProQuest, and SFS-standards were mentioned only once and they are grouped as 'Other'. The shares of the planned information sources are presented in Figure 1.

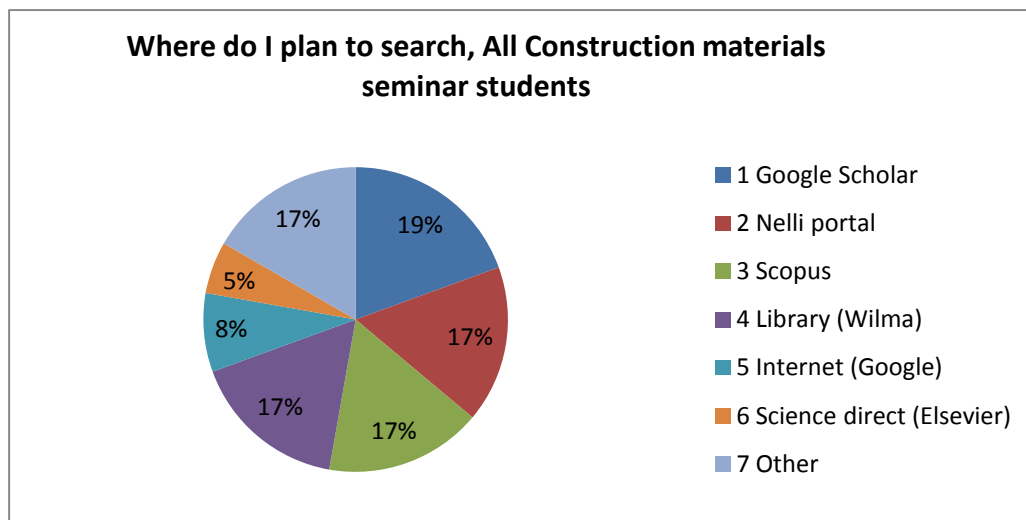


Figure 1. Shares of the information sources

After the IL education sessions, students of the research group were asked where they had searched information. The significant changes in searched sources were in the shares of Library database Wilma (decrease 17 → 0), Science Direct (increase 5 → 14), general Internet sources (decrease 8 → 0). The group 'Others' had grown from 17 to 27 per cent but the sources mentioned in that group were now Springerlink eJournals, EBSCO, Finnish databases, IATE, and Journal Citation Reports. The shares of different information sources after attending IL education are shown in Figure 2.

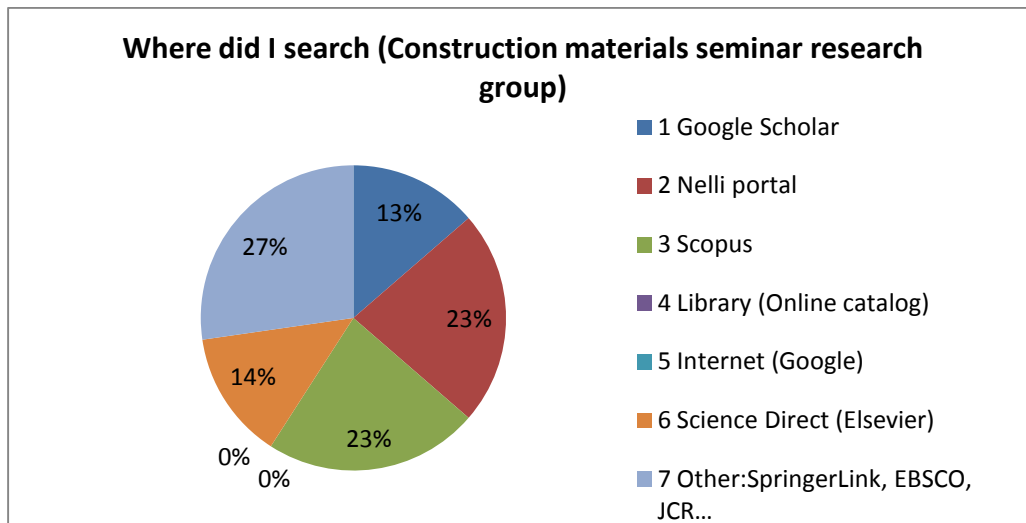


Figure 2. Shares of used information sources after IL education

Results in the Research methods and methodology class differed from the Construction materials seminar class. Prior the IL education they planned to rely on the Library in their information retrieval. They also had a wide variety of sources classified here as 'Other'. In the students' answers these 'others' appear as *Scribde, text book, Master's and PhD thesis, old research works and previous work, journal and conference articles, books, and scientific journals*. Figure 3 shows the shares of planned information sources before IL education.

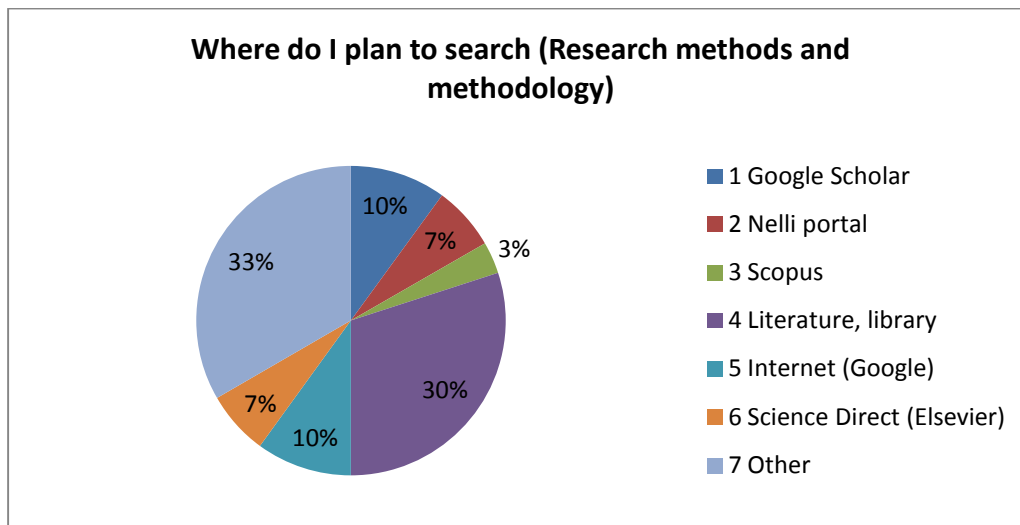


Figure 3. Planned information sources of the Research methods and methodology students before IL education

After the education they searched as shown in Figure 4. The major changes were in the use of the Nelli portal (increase 7 → 37), Scopus (increase 3 → 27), 'Other' (decrease 33 → 0), Library (decrease 30 → 9), and Google Scholar (decrease 10 → 0). Research methods and methodology students are an international, and a more heterogeneous group than the Construction materials seminar students, who are

all Finnish. That is likely to explain the differences in planned information use and the pronounced reliance on the library at the starting point.

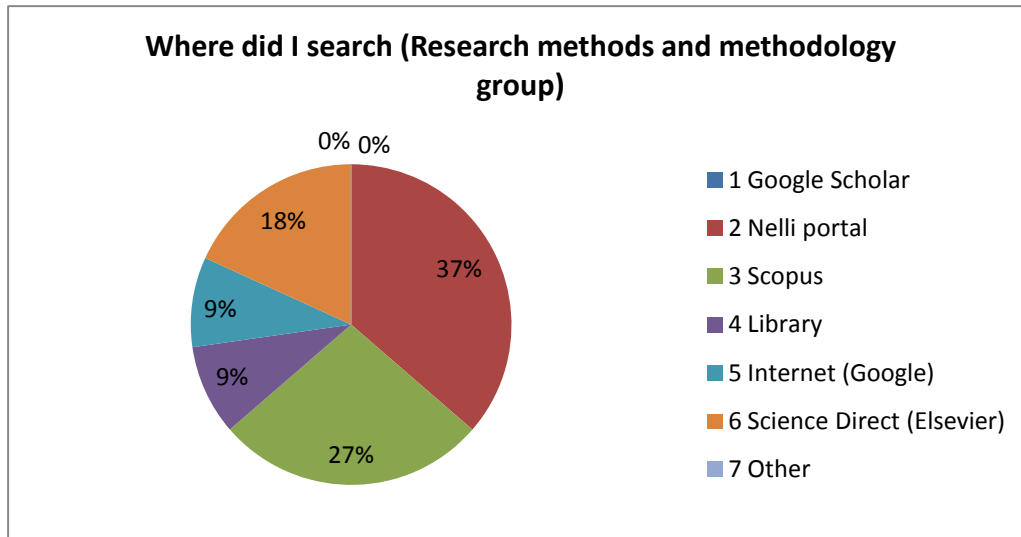


Figure 4. Searched sources in the Research methods and methodology group

3.3. Bibliometric analysis

The bibliometric analysis was performed of the turned-in Construction materials seminar papers. Shares of cited sources are shown in Figure 5 and Figure 6. The differences in results between the research group and the comparison group are great.

Of all citations, the percentage of scientific articles was 58 in the research group while the comparison group scored 29 per cent. The comparison group, on the other hand, used a lot of 'Other' sources but the research group had hardly any of them (6 per cent). Unlike the research group, the comparison group had used undergraduate students' final theses (14 per cent) as references.

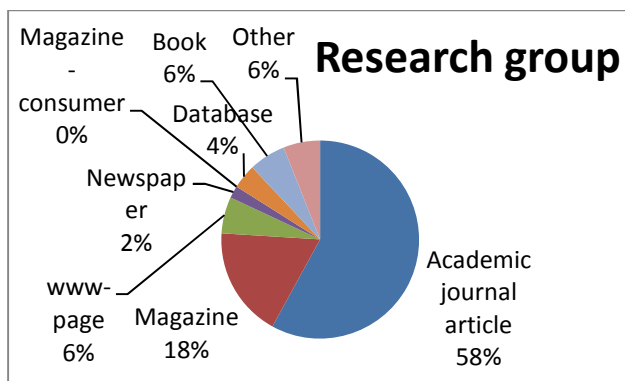


Figure 5. Reference types used by the research group

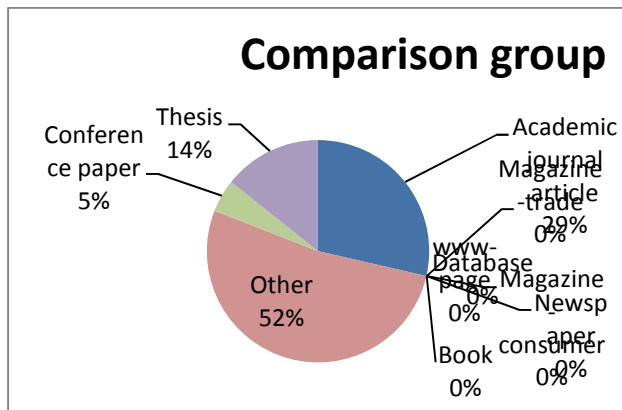


Figure 6. Reference types used by the comparison group

When the publication dates of the referenced material were examined, it was noticed that the research group used mostly very recently published material while the comparison group cited much older sources. The oldest reference used by the comparison group was published in the 80's although they had also some new sources. The oldest citation used by the research group was published in 2003. Figure 7 shows the distribution of publication years of the cited documents.

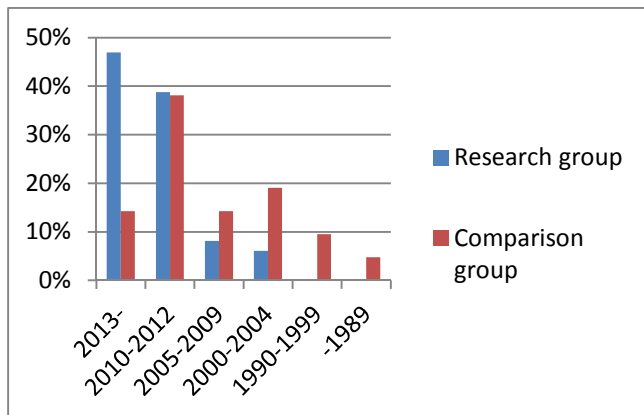


Figure 7. Publication years of the cited documents

There were no significant differences in the numbers of cited sources. On an average the comparison group cited even more sources than the research group. The references were mostly written in English but the comparison group had also used a lot of Finnish sources. On this seminar course, language education is integrated in the course curriculum. The objective of the language education was the acquisition of the necessary basic French or German terminology, as well as key words to facilitate research. Due to this, French and German references were used in both groups.

3.4. How research problems and research questions appeared in the seminar papers

Four seminar works were examined in this pilot research to find out about the impact of IL education on undergraduate engineering students ability to form their research problems and present their research questions. These topics are not part of the IL education curriculum. However, the way of thinking and the mindset taught to the students in connection with information literacy education is similar to the mindset needed to understand research.

In this research, students wrote a literature review on a given subject. The completed papers were analyzed to find out if the research problems and research questions could be seen in the works and if there were differences in the way they were presented. Three out of the four groups had attended IL education and one group worked on the basis of their previous knowledge. All students had already received their Bachelor's degree and thus had done some research before.

Out of the four groups, two presented a clear determination of both the research problem and the research questions. All members of these two groups were among those who attended IL education. One group, whose members also participated in IL education, presented their research problem less clearly but it could be found in the abstract of the paper. The fourth group, which did not participate in IL education, had no noticeable definition of the research problem or research questions.

3.5. How proper literature search affects the substance

The analysis of the substance and the content of the text are based on four selected seminar works. The students in three groups have participated in the literature search lessons and one group has worked individually with the available references and databases. Based on the observations of the written text, remarkable differences can be found.

The results of the literature review affect significantly the quality and substance of the written seminar work. The deeper understanding of the results can be seen in the way how the students were utilizing the references, which they have found. If no teaching about literature search was given, the text in student's seminars looked like copy-pasted paragraphs or chapters based only on the original reference without any connection with student's own opinions. Sometimes the text was close to plagiarism and there was hardly any connection between different paragraphs and different references. The utilized references seemed to be used mostly to produce more text and words to fulfill the required length of the exercise. The opposite of this were the seminar works written by the students who have received advice about proper literature search. Their seminar works were based on the dialogue with the found references and the meaning of each reference is explained in the context of the seminar topic. In their seminar works, the utilized references seemed to form a logical chain with some essential themes or key aspects. There was a clear focus in the chapter entitled "literature review".

The students who had participated the lessons of literature search were able to search and find references which answered more to the research questions starting with the word "why" than simplified questions starting with the words "what", "where" or "when". This was one of the key results in this article: proper way to understand and carry out literate research helps students to formulate and analyze the research problem so that the reasons and consequences of different phenomena will be discussed in their seminar works. E.g. the seminar work entitled "Special aspects in the material selection process of protective structures in a nuclear power plant" included not only the research question of "what materials are used for protective structures" but also the justification of "why they are used" was included. The students without lessons of literature search only collected references and they seemed to be satisfied in presenting just the existing facts without any interpretation or own thoughts about the content of the references.

If the students had learned how to use effectively different operations and techniques to find high quality references they seemed to be able to present the results of the literature search in various and illustrative ways. They were able to describe the development of the researched topic in a logical timeline or they presented the results either in a comparison or SWOT analysis table. These aspects were important e.g.

in the seminar work, in which the students wanted to explain the importance of trying to find better ways for recycling rare earth metals.

One remarkable observation was that if the students have learned how to carry out the literature search properly they were also aware that some of the references might support their own results but they were not shocked if some references might present even opposite viewpoints. E.g. the seminar work dealing with “The use of high strength steels in automotive industry” was a good example of this kind of objective use of references. On the other hand, the students without those lesson were mostly looking for articles and other references which best supported their own ideas and thoughts.

Good literature search skills affected also the diversity of utilized references. If the literature search was carried out properly, some of the references were used to form the background for the seminar work and the others were utilized as case examples and maybe the third groups could have been used to verify the conclusions.

The proper way to carry out the literature search could be seen also from the conclusion or discussion chapters of the seminar work. If the students were aware of how to ensure the high quality and reliability of the references they were also able to describe these aspects in their seminar work to convince the reader about the relevance and reliability of the written text. Some of the students had even used so-called triangulation to verify the results. This is possible, if the students know how to ensure that some articles and/or the databases are independent and if they know the ways to ensure that some articles really are the original ones. Many of the students have learned during the literature search lessons how to use the tools of some commercial databases to carry out the bibliographic analysis. These kinds of observations have been made e.g. in the seminar work entitled “Special aspects in the material selection process of protective structures in a nuclear power plant”.

In addition to this content analysis, the used sources could have been observed considering factors that describe their scientific quality. Factors that would apply here are for example impact factors, SNIP and SJR values. The limitations of these factors are evident because, for example, they are not used in all databases. However, it can be assumed that the quality that is measured by these factors can be seen in the final papers.

4. Conclusion

Based on the results of this pilot study it is evident that IL education has a positive effect on undergraduate engineering students’ information searching behavior and on their ability to do scientific research. Key findings of this paper were that after the IL education

- information searches improved
- the quality of found and used sources improved
- students expressed deeper handling of the subject
- students understood better how to turn the research problem into the process of information retrieval and use

However, the pilot group was very small. Therefore, the study should be repeated in a larger scale to ensure the findings. Moreover, to verify the results the study should be extended to other disciplines but mechanical engineering. These kinds of studies have already been planned for the coming semester. Later the study will be widened to include the comparison of relevant bibliometric indicators.

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