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INVESTIGATING THE INVOLVEMENT OF SELF-DIRECTED LEARNING IN FLIPPED CLASSROOMS: A UNIQUE URL-BASED SEARCH METHOD

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ABSTRACT

Ability to engage in lifelong learning requires the individuals to possess self-directed learning skills. ABET student outcome 3.i states that upon graduation a student should be able to demonstrate "*a recognition of the need for, and an ability to engage in lifelong learning*". The challenge is in instilling these skills to students in traditional learning environments. In an effort to overcome this challenge, educators developed and implemented various approaches; one being the flipped classroom approach. One challenge when conducting research for self-directed learning environment in flipped classrooms is the challenge of finding relevant papers using keywords search. Terms, such as "flipped classroom" and "self-directed learning" may be included in relevant papers but not necessarily together. And searching these keywords separately will yield results that might have overlapping papers. This paper presents a unique URL-based literature search to identify the publications in the areas of self-directed learning in flipped classrooms by improving keyword-based literature search. It is followed by a title text analysis that will be used to identify the most common discussed topics in the database search results. In addition, an overview of how these methodologies can help the researchers identify the most relevant publications in the research area is presented. Challenges, observations and outcomes of both search methods are explained and analysis plots are presented.

INTRODUCTION

For many years, innovative teaching methodologies are subject to investigation to adapt curricula and course delivery methodologies for advancing science and technology as well as to help students be lifelong learners [1]. Lifelong learning is especially an important part of engineering and technology education as supported by the ABET student outcome. As the importance of lifelong learning increased in industry, it triggered the educational institutions to develop their contents so that students gain "the ability to continue learning without the direct interaction with an educator" [2]. There are multiple avenues for lifelong learning to occur [3]. Since engineering, science and technology education experience a rapid obsolescence [4], self-directed learning is one of the most effective methods to employ lifelong learning starting from freshman level courses [5-6] to multidisciplinary senior level courses including project based capstone projects [7-10]. Another common approach is to improve course delivery methods especially for multidisciplinary project based courses [7,8,11,12] and activity based learning [13].

Many educational institutions and programs employed self-directed learning components to teach their students the lifelong learning skill set. These innovative components vary from tutorials to modules from freshman to senior level courses [14]. Especially when it comes to multidisciplinary projects such as mechatronics [15] and robotics [7]; one major challenge becomes the time limitation [16] since these types of projects have many subcomponents that require longer time to complete. These multidisciplinary projects are offered at any level from sophomore to senior year; and it is expected that students may not possess all the necessary skills and may be required to improve their knowledge on their own [17,18]

One of the ways to provide students a platform for them to practice their self-directed learning skill as well as to overcome time limitation challenge is the flipped classroom environment [19-23]. Flipped classroom approach shifts the act of learning prior to the class and gives students a chance to learn the subject matter on their own. With this approach, instructor shares the learning material prior to the class, and students are expected to review the shared lecture materials and learn the basics of the subject. The class time is then used to identify more advanced portion of the subject, solve questions, carry out discussions and work on projects. Although flipped classroom approach motivates students to be self-directed learners, it can also be very challenging for the students and instructor, if

students are not familiar with the concept of self-directed learning [24].

Self-directed learning, and related concepts; such as flipping the classroom, has been an active research stream in the field of education. With that we have seen an increase in the use of relevant phrases in papers (e.x. "self-directed learning", "self-regulated learning" and "flipped classroom"). This helps for example when we search online databases to explore sub-topics and how they trend over the years. However, these phrases do not exist in papers mutually exclusively. And if one phrase is searched, resulting papers may include other phrases. Therefore, relying only on the existence of a keyword provides a limited analysis of the topic. For example, finding papers that are only about unique topics is not possible by only looking at the existence of relevant keyword. In this work, authors study the searching of papers when papers include multiple phrases. The next section explains the proposed method and findings when the method is applied to a list of papers that includes the following keywords: "self-directed learning", "self regulated learning" and "flipped the classroom".

In this paper, the authors conducted a database search to collect information and review the prior studies regarding self-directed learning and flipped classrooms. One of the challenges authors ran into is the varying and non-unified terminology. The term "self-directed learning" is used interchangeably with "self-learning" and "self-regulated learning". This created the challenge in literature review and finding the most relevant papers. Another challenge authors faced was the clustering the literature of same topic. To classify the literature, the authors initially conducted a keyword search. Although the keyword search provided a comprehensive list of publications; it also created the challenge of one or many papers showing up more than once as a part of different keyword searches. To overcome this challenge a secondary search method is developed and employed. In this method a unique URL-based keyword search is completed. This approach ensured that each paper will only appear once in the search results and there won't be any repetitive appearances. This paper provides an overview of keyword-based search and unique URL-based keyword search, and the most relevant publications to the keywords are identified. Following sections discuss the review methodology in depth followed by analysis, conclusion and future work.

DATABASE REVIEW METHODOLOGIES

In this study two search methodologies are employed. The first methodology is a keyword-based search, where five searches are executed with three different keywords. The second search methodology is the unique URL-based keyword search. This search uses the keyword search databases to complete a descriptive search approach. For both search methodologies ASEE Peer is used as the search database.

Keyword-Based Search

In the keyword based search five different searches conducted. In these searches three different keywords and their combinations are used. The database used to conduct the keyword searches is ASEE Peer database. Search rules are: (i) only proceedings published after 01/01/2010 are considered and (ii) only ASEE Annual Conference proceedings are considered.

The keywords used are: "self-directed learning", "self-regulated learning" and "flipped classroom". The reason both self-directed learning and self-regulated learning are used as keywords is that, there are studies that only employ the use of one of these terminologies and we are interested in reaching all the studies in the area of self-directed/regulated learning.

Search 1 – Keyword: "Self-Directed Learning"

The keyword search of "self-directed learning'' resulted in a total of 269 conference proceedings. The yearly distribution of these conference proceedings is shown in Table 1. This table shows that the appearance frequency of the keyword "self-directed learning" increased over the years. Although, this is not a continuous increase, the pattern suggests that more studies are conducted with the self-directed learning concept.

Table 1. Keyword Search Results for "Self-directed Learning"

Keyword: "Self-directed Learning"	
ASEE Annual Conference	**# of Papers**
2010 Annual Conference & Exposition, Louisville, Kentucky	28
2011 ASEE Annual Conference & Exposition, Vancouver, BC	36
2012 ASEE Annual Conference & Exposition, San Antonio, Texas	28
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	34
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	43
2015 ASEE Annual Conference & Exposition, Seattle, Washington	51
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	49
Grand Total	**269**

Search 2 – Keyword: "Self-Regulated Learning"

The keyword search of "self-regulated learning" resulted in 222 conference proceedings. The yearly distribution of these proceedings is shown in Table 2. With the self-regulated learning keyword, there is a continuously increasing trend in the frequency of the keyword's use over the years up until 2016. In 2016, there is a very slight decrease. However, the use of the keyword almost quadrupled over the last seven years.

Table 2. Keyword Search Results for "Self-regulated Learning"

Keyword: "Self-regulated Learning"	
ASEE Annual Conference	**# of Papers**
2010 Annual Conference & Exposition, Louisville, Kentucky	13
2011 ASEE Annual Conference & Exposition, Vancouver, BC	18
2012 ASEE Annual Conference & Exposition, San Antonio, Texas	21
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	20
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	35
2015 ASEE Annual Conference & Exposition, Seattle, Washington	60
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	55
Grand Total	**222**

Search 3 – Keyword: "Flipped Classroom"

The keyword search of "flipped classroom" resulted in 304 conference proceedings. The yearly distribution of these proceedings is shown in Table 3. The flipped classroom approach is a fairly new approach, and as it can be seen from

the keyword search results, there were no published studies in this area in the years 2010 and 2011. Starting from 2012, we see a continuous increase in the use of the keyword with the exception of 2016, where we see a slight decrease. From the keyword search results, it can be observed that flipped classroom approach quickly became a very popular teaching methodology.

Once the individual keyword searches are completed, second level keyword searches are conducted. These searches are the two-keyword searches. Searches 4 and 5 provide the outcomes for the two-keyword search results for "self-directed learning" & "flipped classroom", and, "self-regulated learning" & "flipped classroom" respectively.

Table 3. Keyword Search Results for "Flipped Classroom"

Keyword: "Flipped Classroom"	
ASEE Annual Conference	**# of Papers**
2010 Annual Conference & Exposition, Louisville, Kentucky	0
2011 ASEE Annual Conference & Exposition, Vancouver, BC	0
2012 ASEE Annual Conference & Exposition, San Antonio, Texas	2
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	25
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	61
2015 ASEE Annual Conference & Exposition, Seattle, Washington	109
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	107
Grand Total	**304**

Search 4 – Keywords: "Self-Directed Learning" and "Flipped Classroom"

The keyword search of "self-directed learning" and "flipped classroom" together resulted in 20 conference proceedings. The yearly distribution of these proceedings is shown in Table 4. Since the result of this search is dependent on the individual keywords, and since the "flipped classroom" terminology was first appeared in the search results in 2012; it is not surprising to see that the first study that involves self-directed learning and flipped classroom appears in 2013 conference proceedings.

Table 4. Keyword Search Results for "Self-directed Learning" and "Flipped Classroom"

Keyword: "Self-directed Learning" and "Flipped Classroom"	
ASEE Annual Conference	**# of Papers**
2010 Annual Conference & Exposition, Louisville, Kentucky	0
2011 ASEE Annual Conference & Exposition, Vancouver, BC	0
2012 ASEE Annual Conference & Exposition, San Antonio, Texas	0
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	2
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	6
2015 ASEE Annual Conference & Exposition, Seattle, Washington	7
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	5
Grand Total	**20**

Table 5. Keyword Search Results for "Self-regulated Learning" and "Flipped Classroom"

Keyword: "Self-regulated Learning" and "Flipped Classroom"	
ASEE Annual Conference	**# of Papers**
2010 Annual Conference & Exposition, Louisville, Kentucky	0
2011 ASEE Annual Conference & Exposition, Vancouver, BC	0
2012 ASEE Annual Conference & Exposition, San Antonio, Texas	0
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	3
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	3
2015 ASEE Annual Conference & Exposition, Seattle, Washington	1
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	7
Grand Total	**14**

Search 5 – Keywords: "Self-Regulated Learning" and "Flipped Classroom"

The keyword search of "self-regulated learning" and "flipped classroom" together resulted in 14 publications as seen in Table 5. The results of this second level keyword search follows the same pattern as Search 4, where there are no publications during years 2010, 2011 and 2012. First study that involved "self-regulated learning" and "flipped classroom" keywords appear in 2013 conference proceedings.

Keyword-Based Search Observations and Challenges

The keyword-based search approach provided results based on the specific keywords or key phrases, and which years these keywords most used. Figure 1 below shows the distribution of the papers by keywords over seven years, 2010-2016.

We were able to observe and understand the pattern of the frequency of these keywords over a seven-year period from 2010 through 2016. Although keyword-based search is effective, it has the challenge of double counting a publication when multiple keywords are used together or individually. As an example one or more paper may appear multiple times under different keyword searches and keyword search combinations. One way to catch the papers that appear multiple times under different keywords is to conduct a manual search. However, as it can be imagined, this is a very time consuming activity, and the chances of missing papers is very high. To address this challenge a second search methodology is employed: unique URL-based search.

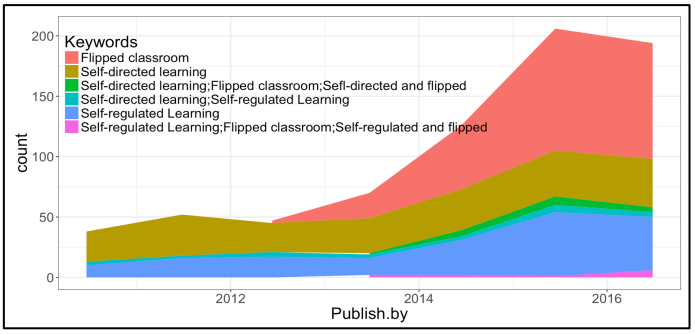

Figure 1. Keyword search results for 2010 - 2016

Unique URL-Based Search

Every paper in the ASEE Peer database has a unique URL attached to them. One easy way to "catch" the papers that appear multiple times in different keyword or keyword

combination searches is to base the search on these URLs. An R code is developed to search for unique URLs, so that papers that are common to different keywords can be identified. The R code used the lists that are obtained from each of the previous keyword searches. Seven different searches are completed through the unique URL-based search method. The outcomes of the unique-URL based search are presented in Table 6 for the following keywords:

A: "Self-directed Learning"
B: "Self-regulated Learning"
C: "Flipped Classroom"
D: "Self-directed Learning" and "Flipped Classroom", "Self-directed Learning", "Flipped Classroom"
E: "Self-regulated Learning" and "Flipped Classroom", "Self-Regulated Learning", "Flipped Classroom"
F: "Self-directed Learning", "Self-regulated Learning"
G: "Self-directed Learning", "Self-regulated Learning", "Flipped Classroom", "Self-Directed Learning" and "Flipped Classroom" "Self-Regulated Learning" and "Flipped Classroom"

Table 6. Unique URL-based keyword search results 2010-2016

ASEE Annual Conference & Exposition	A	B	C	D	E	F	G
2010	25	10	0	0	0	3	0
2011	34	16	0	0	0	2	0
2012	24	17	2	0	0	4	0
2013	29	24	21	1	2	3	1
2014	34	29	53	5	2	3	1
2015	38	53	101	7	1	6	0
2016	40	44	96	4	6	4	1
Grand Total	224	193	273	17	11	25	3

Unique URL-Based Search Observations and Challenges

The URL-based keyword search provided the methodology to identify the papers that are unique and prevented the same study to appear multiple times. The unique URL-based search was completed using R. R is open-source programming software that enables the user to develop their own code. One needs prior working and programming knowledge of R in order to develop the necessary code for the URL-based search, which may be considered as a challenge of the approach.

The observations from the results of the unique URL-based search showed us that there are three studies that are presented and published in the 2013, 2014 and 2016 ASEE Annual Conference proceedings that have all the keywords and the combinations of the keywords appear. From our search approach and based on our search criteria, it is concluded that these three papers are the most relevant papers. These three papers are identified based on their unique URLs as are shown in Table 7.

Table 7. Most relevant papers - Unique URL-based keyword search

ASEE Conference	URL	Paper Title	Authors	Division	Session Name
2013 ASEE Annual Conference & Exposition, Atlanta, Georgia	https://peer.asee.org/22445	Self-Regulated Learning and Blended Technology Instruction in a Flipped Classroom	Kenneth A Connor, Rensselaer Polytechnic Institute; Dianna L Newman, University at Albany/SUNY; Meghan Morris Deyoe, University at Albany, SUNY	Electrical and Computer	ABET Accreditation, Assessment and Program Improvement in ECE
2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana	https://peer.asee.org/20506	Flipping a Classroom: A Continual Process of Refinement	Kenneth A. Connor, Rensselaer Polytechnic Institute; Dianna L. Newman, University at Albany/SUNY; Meghan Morris Deyoe, University at Albany, SUNY	Electrical and Computer	Flipping ECE Courses
2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana	https://peer.asee.org/26138	The Effect of Soft Classroom: A New Learning Environment Integrating MOOCs into Conventional Classrooms for College Students	Shih-Chung Jessy Kang P.E., National Taiwan University; Yifen Li, National Taiwan University; ChingMei Tseng	Engineering Design Graphics	Pedagogy and Learning Within Engineering Design Graphics II

One of the observations that can be drawn from the outcomes of the unique URL-based search is that there is a positive correlation between the self-directed & self-regulated learning and flipped classroom studies, shown in Figure 2. The correlation can be modeled by a third order polynomial trendline. The correlation suggests that as the flipped classroom studies increased, so did the self-directed learning & self-regulated learning studies. Therefore; it can be concluded that the use of self-learning concept increased as more flipped classrooms are used.

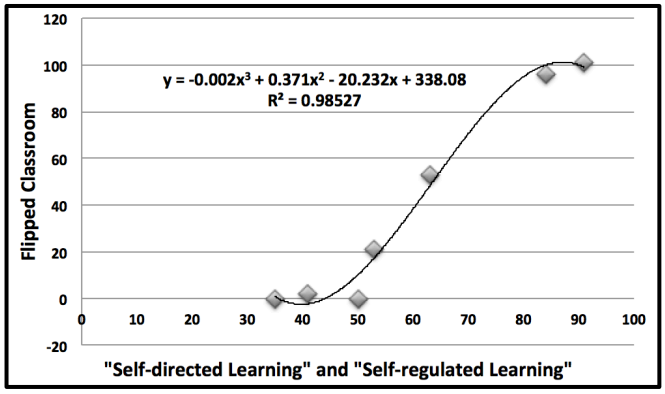

Figure 2. Correlation between the combined Self-directed learning and Self-Regulated Learning & Flipped Classroom

TITLE ANALYSIS

Once the keyword-based search and the unique URL-based search are completed, the next step is to identify what are the most common topics that are discussed in these papers. One way to analyze and identify the research discussed in these papers is to conduct a title analysis, as the titles are specifically created to "summarize" the research. In this paper, we completed three different title analyses: the first title analysis is completed for the "self-directed learning" keyword, the second title analysis is completed for "flipped classroom" keyword, and the last title analysis is completed for the all the studies that are in the "self-directed learning", "self-regulated learning" and "flipped classroom" keywords.

To conduct text analysis, R software was used. In particular we used a recently introduced text analytics package: quanteda[25]. To focus on the parts of the titles that have higher semantic values, we eliminated the words that are too common and mostly functional – such as "the", "and"– from

each title. These were commonly referred to as *stopwords* and they are usually excluded from text analytics as they offer little information about the text being analyzed. We used the stopword list that the quanteda package offers for the English language.

Next, we reduced the words to their stems (a process called stemming) to remove derivational affixes. This way, words derived from the same root are grouped together (e.x. *innovative* and *innovation* are converted to *innov*).

In addition, we removed the words that occur too frequently in our title list as they relate to the high level theme of the selected papers. For example, for all the titles, top 5 words were: engin(eering), 360; learn(ing), 241; cours(e),179; design, 101; classroom 101. These words, arguable indicate, that majority of the papers are about engineering education, which was not surprising considering the keywords we used to populate our dataset. We then, proceed to plot word clouds for each search results. In each plot, font size indicates the frequency of the word occurrence. The words are placed randomly in these plots.

Self-Directed Learning Title Analysis

When the self-directed learning keyword papers' titles are analyzed, the rule that was set to plot the words that appears in the titles 100 times or more. As it can be observed from the Figure 3 below the words that catch the attention are: "skill", "program", "project-based", "problem-based", "capstone", "technology", and "outcome". When these words are examined they clearly give us a picture of the topics self-directed learning papers discuss the most. Since the self-directed learning activity requires the students to possess the self-learning skill, "skill" is one of the common words these papers share. Usually there is an activity involved as a part of the coursework to provide students a platform for them to carry out self-directed learning, and as it can be seen from the title analysis project-based and problem-based activities are frequently employed. Other most common words are capstone, senior and build; which indicates that the self-directed learning is also commonly a part of the capstone design class and senior level students practice the self-directed learning as they build their projects, which also is compatible with project-based learning.

Figure 3. Title Analysis Results for "Self-directed learning" keyword

Flipped Classroom Title Analysis

For the "flipped classroom" keyword, the title analysis resulted in the following words to be identified as the some of the most common appearing words in the titles: "project-based", "self-directed", "multidisciplinary", "evaluation", "prepare", "industrial", "attitude", "transform" and "service". Figure 4 provides the results of the flipped classroom title analysis. When examined, these words give us clear understandings of what are the most common topics discussed in the flipped classroom related studies. As expected self-directed learning is one of the most common appearing words, emphasizing self-directed learning has a very important role in flipped classrooms. Project-based and multidisciplinary words give us an insight on the type of the projects that are employed in the flipped classrooms. The words "attitude" and "cognitive" summarizes that studies examined students' cognitive learning of the concepts, attitude towards flipped classrooms and self-learning.

Figure 4. Title Analysis Results for "Flipped Classroom" keyword

Overall Title Analysis

In the complete title analysis all the titles from all keyword searches are examined. The results of this overall title analysis are shown in Figure 5. As a result of this complete analysis approach, "research", "problem-based", "lifelong", "self-regulated", "hands-on", "self-directed", "self-efficacy", "engaged", and "mechanical" are some of the most repeated title words. The overall title analysis provides us a great insight as to what are the most discussed topics in these research papers. From the overall title analysis it can be concluded that research and problem-based components are commonly employed in flipped classrooms and self-regulated and self-directed learning are a part of the learning process in flipped classroom settings. Studies measured self-efficacy and student engagement. We also observe that, mechanical engineering, electrical engineering, civil engineering and chemical engineering are the degree programs that appear in the titles in the rank of appearance, respectively.

Figure 5. Overall Title Analysis Results

CONCLUSIONS AND FUTURE WORK

This paper presented a unique URL-based keyword literature search methodology to identify the publications in the areas of self-directed learning in flipped classrooms. In addition, text analyses of the titles of the search results are conducted. The contribution of the study is twofold: a methodology to search for topics in the literature and the analysis of the relevant papers.

The proposed methodology related outcomes are:

(i) The unique URL-based methodology provided the opportunity to search a database to identify and find the relevant unique papers without any paper being double counted or missed.

(ii) The unique URL-based methodology can be customized to search for any keywords, databases and more keywords.

(iii) The use of title analysis can be used to analyze the content of the papers based on their titles.

The findings of the content analysis showed:

(i) "self-directed learning" and "self-regulated learning" in ASEE conference increased exponentially since 2010.

(ii) There is a positive polynomial correlation between the flipped classroom and self-directed and self-regulated learning approaches. This outcome suggests that increased use of flipped classroom approaches resulted in higher implementation of self-regulated and self-directed learning approaches.

(iii) Word occurrences in titles provide us an overview of the most related and discussed topics in these papers.

The use of unique-URL based search provided us the opportunity to understand trends based on phrases, not just keywords; in addition since the methodology is concept-based, we were able to see the correlations otherwise wouldn't be visible. With the implementation of the unique-URL based search combined with the title analysis, we were able to achieve our goal of getting an insight to the research without too much focusing on the generating mechanisms of the number of papers. Our future work is to continue and expand the search to gain more in-depth insight to multiple conference and journal databases through unique-URL based search methodology.

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