A Cloud-Internet based approach using machine learning methods to assess the quality of course learning outcomes

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Abstract
Over the past decade, the achievement of Course Learning Outcomes (CLOs) have become the cornerstone for ensuring the quality of graduates in higher education institutions. In practice, the formulation of the appropriate course learning outcomes along with the teaching strategies and assessment methods support the high achievement of students learning. Although, most of the accreditation agencies locally and internationally provide clear guidance about the program learning outcomes, the investigation of the course learning outcomes has received less attention. In addition, the establishment of the appropriate course learning outcomes according to the required level of learning and course requirements is considered as an issue of big challenge and complexity. In practice, the challenge is evident through (1) the big variations of CLOs between similar courses in similar disciplines and (2) the inappropriateness of CLOs with respect to the level of required learning at the course and program levels. In this paper, we propose a novel approach to evaluate the quality and compatibility of CLOs against a set of ideal course learning outcomes that meet well-defined measurement criteria of good CLOs. In doing so, a set of CLOs for core courses in several disciplines have been collected and prepared according the criteria of good CLOs. We apply machine learning methods to rank the learning outcomes against a gold standard set of ideal CLOs. We use a dependency parser to parse the text of the learning outcomes and find similar words through a word embedding model which are fed it to our decision tree built from the gold standard to measure the quality of the new unseen CLOs. The results of our approach show very impressive results in measuring the quality of new CLOs against a set of standard CLOs.

Key words:
Course learning outcomes, Quality Education, Dependency Parser, Word Embedding Model.

1. Introduction

In the field of higher education, the outcome-based approach has become a crucial requirement in assuring the quality of the academic programs. In practice, the academic programs including curriculum, courses and other educational and instructional practices are built upon the notion of learning outcomes that describe what students are expected to do and know by the end of the learning period [1]. Moreover, the standards and criteria of the current academic accreditation commissions emphasize the development, delivery, assessment and evaluation of learning outcomes [2]. Fig. 1 shows the complete cycle of outcome-based education (OBE) at the course level. It is clear that the requirements of the OBE continuous improvement cycle start with the establishment of course learning outcomes that are followed by the appropriate learning experience (teaching, educational practices, etc.) and the assessment of learning.

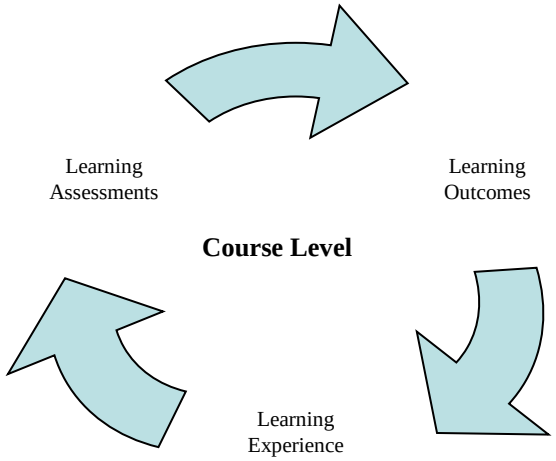

Fig. 1 Course Level Learning Outcomes

That being said, the first step in the outcome-based approach requires the establishment and examination of the appropriate program and course learning outcomes. Although the accreditation agencies (e.g. Accreditation Board for Engineering and Technology ABET) and the national qualification frameworks (e.g. Saudi Arabia Qualification Framework) provide a clear guidance and even a set of well-defined learning outcomes at the program level, the establishment and investigation of the course learning outcomes has received less attention [3]. Moreover, the great disparity between the learning outcomes of similar core courses in the same disciplines represent a lack for the enablement of the program learning outcomes [4]. In addition, the inconsistencies between the main topics of the courses with their learning outcomes may lead to invalid delivery and assessment of the learning outcomes. Hence, the academic programs are eager to establish and examine the suitable and appropriate course learning outcomes to achieve high level attainment of students' skills, behaviors

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and attitudes. Therefore, the key question to address is "how can a program assess the quality (appropriateness and compatibility) of their course learning outcomes (CLOs) compared to the ideal CLOs". By assessing the quality of CLOs, we mean the appropriateness and compatibility of the learning outcomes according to a set of well-defined CLOs that meet the national and international criteria.

More specifically, the Kingdom of Saudi Arabia (KSA) pays a massive amount of money in the teaching and learning process especially the establishment and assessment of learning outcomes through the NQF standards, Educational Evaluation Commission (EEC) and National Center for Assessment (QIYAS) [5]. The main reason of this research project is to help with this aspect by ensuring compatible Course Learning Outcomes (CLOs) that will guide the delivery of courses as well as the assessment of student knowledge and skills at the course level. Below are the key problems that most of the academic programs in Saudi universities and worldwide are faced:

- The great disparity between similar courses in different universities.
- The absence of a clear mechanism to determine the suitable and appropriate Course Learning Outcomes according the national and international standards.
- Inconsistencies between CLOs and the main topics of the course.
- The appropriate alignment of the CLOs to the appropriate program learning outcomes to ensure that the courses enable students to attain the required skills and knowledge by the time of graduation.

To the best of our knowledge, there is no such approach to overcome the aforementioned challenges and problems related to ensure high quality achievement of student outcomes by the end of the courses and programs. In this paper, we focus on measuring the quality of CLOs which is considered one of the main stepsss for achieving high quality standards.

This paper is organized as follows. Section two discusses the related works. Section three describes the research objectives and issues, section four represents the research methodology implemented to develop the machine learning methods to assess the quality of CLOs. Section five discusses the main proposed approach. Section 6 shows the results of the proposed approach. Finally, Section 7 discusses the conclusion and future work.

2. Related work

The education paradigms and strategies have been shifted from the content-based education to the outcome-based education that emphasizes the process of education around the learning outcomes of students [6, 7]. Learning outcomes are the statements that define what skills, knowledge and attitudes students will acquire by the end of a learning process (e.g. at the end of the program or course) [8]. The program learning outcomes could be used in the designing of the curriculum and courses because it refers to the skills and knowledge the students are expected to acquire by the time of graduation [6]. On the other hands, the course learning outcomes specify what students are expected to achieve by the end of the course [7]. In literature, there are enormous number of criteria for writing the appropriate learning outcomes at various levels. For instance, these criteria include the specificity, measurability, acceptability, and realistically. The classification of bloom's taxonomy in various domains (cognitive, affective and psychomotor) support the establishment of learning outcomes in different domains at various levels of complexities.

The Saudi National Qualification Framework (NQF) describes in more details important points to consider about the use of domains of learning when formulating learning outcomes at the program and course levels as well as educational and assessment practices in order to meet the national and international standards [3, 4, 9]. On the other hand, the Education Evaluation Commission (EEC) established the system for accreditation and quality assurance in the Kingdom of Saudi Arabia to ensure that the quality of higher education is equivalent to high international standards. Through the accreditation process, the EEC evaluators check manually if each course meets the following [5]:

- A set of course learning outcomes (maximum 12 outcomes per course) that are classified in the five domains of learning areas defined in the Saudi NQF.
- CLOs are aligned with the intended learning outcomes at the program level.
- CLOs have three main components (action verb + content + criterion for measurement).
- CLOs are consistent with course description and topics.

In 2012, the National Center for Assessment in Higher Education (QIYAS) in Saudi Arabia launched a project (1) to develop a set of unified intended learning outcomes and performance indicators for all academic programs (2) and to subsequently prepare a unified qualification exam based on the developed learning outcomes. Since all graduates in the Saudi institutions are required to take the qualification exam and meet the national and international learning outcomes, therefore, it has become very necessary to ensure that course learning outcomes of the curricula meet those learning outcomes [10].

The machine learning methods (dependency parser, word modelling, decision trees, etc.) have been widely used in various areas including education, health, economic, etc. [12, 13, 14]. In the literature of education, the machine learning techniques have received a great deal of researcher's focus especially the classification of questions and learning outcomes into bloom's taxonomy [11]. However, the formulation of learning outcomes using ML

techniques (Natural Language Processing NLP, etc.) has not presented in the literature because there is no general agreement of the CLOs between similar programs that operate under the umbrella of the same country. For this reason, it becomes very crucial to develop an automated approach to analyse and evaluate the compatibility of course learning outcomes.

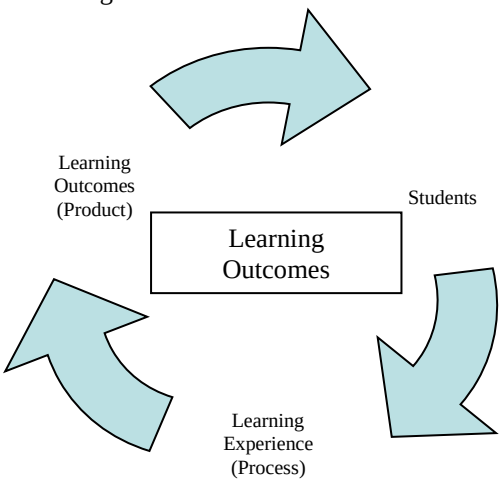

Fig. 2 Learning outcomes processes

3. Research Objectives and Issues

To the best of our knowledge, there is no approach that neither assesses the quality of the CLOs nor supports the academic programs to evaluate the appropriateness and compatibility of their CLOs. However, there huge number of papers in the literature that show various techniques in assessing the attainment of learning outcomes at the program and course levels [23, 24]. In addition, there are various software such as CLOSO and Evaltools [25, 26] that support the automation of assessing the attainment of course learning outcomes. Although the literature research papers and the automated systems support the assessment and evaluation of learning outcomes, they are neither supporting the formulation of good CLOs nor the evaluation of their compatibility and appropriateness. This paper discusses a framework based on machine learning methods to evaluate the compatibility of CLOs compared to a set of good CLOs [27]. This paper supports the academic programs to perform the following:

- To assess the quality of the CLOs by using our machine learning approach. Specifically, machine learning techniques are used to evaluate the compatibility and appropriateness of the CLOs against a set of ideal CLOs for the same course.
- Write the appropriate course learning outcomes by using a set of well-defined criteria of good learning outcomes. These criteria include the number of learning outcomes per course, levels of actions verbs, alignment of the learning outcomes with the course topics, etc.
- The objectives of this paper are to:
- Analyze Course Learning Outcomes (CLOs) of core courses.
- Identify benchmarking CLOs for some core courses according to the Saudi National Qualification Framework (NQF) and the level of learning of those courses.
- Use machine learning techniques (e.g. dependency parser, word embedding model, etc.) to evaluate the percentage of compatibility between the available CLOs in the Saudi Universities against the benchmarked CLOs.
- Minimize the gaps between the quality of CLOs of similar programs (e.g. computer science programs in different institutions).
- Support academic programs in Saudi Universities to formulate the appropriate CLOs according the NQF standards and the level of learning in the course.
- This research addresses the following issues:
- Identify a set of measurement criteria to measure the quality of Course learning Outcomes (CLOs) using the National (Saudi) and international standards.
- Develop a set of ideal CLOs for key courses in the computing disciplines (computer science core courses). When we say “ideal”, we are implying that the CLOs are very consistent with the measurement criteria and standards.
- Apply Machine Learning techniques (ML) to evaluate the percentage of quality of CLOs. The result of this step will support the academic programs to have good CLOs that match the required standards.
- Academic programs may use our proposed framework to decide about the quality of their CLOs.
- Academic programs may use our approach to compare the quality of their CLOs with the quality of CLOs in other universities.

4. Research Methodology

This research uses the cloud-based approach and machine learning methods to improve the educational environment. To achieve the goals of this research, we used the following three steps:

- Gathering information: we collected information from selected higher education institutions inside the Kingdom of Saudi Arabia regarding their work and experience with course learning outcomes. The main goal of this step was to create a set of good CLOs for key courses in the computer science major.

- Defining the main criteria of a good course learning outcomes. In this step, deep studies were conducted to define the structure of good CLOs according to the international standards, NQF standards, Saudi EEC requirements, and QIYAS unified learning outcomes. Besides, individual interviews and online surveys took place. We concluded that a good CLO must have three main components (1) an action verb, (2) content of the CLO, and (3) criterion or standard for measurement. For example, "Write a computer program using JAVA language" is an example of a good CLO.
- Applying machine learning approaches to assess the quality of CLOs with a standard (ideal) CLOs. The end result of this step is the matching percentage between the IDEAL CLOs and the testing CLOs.
- Build a cloud-internet based approach to assess the quality of CLOs for any universities in the Kingdom.

5. Proposed Approach

Most of the computing programs (CS, IS, etc.) in KSA, especially, computer science is working under the umbrella of the Accreditation Board for Engineering and Technology (ABET) and the national standards. For instance, we collected data for more than 30 computing programs in KSA. We found that 66% have obtained ABET accreditation, 27% have set their plans to obtain ABET, 7% have made no effort to obtain ABET. For instance, ABET requires computer science programs to meet the ABET (a-k) presets student outcomes (what students will do and know by the end of the program). Therefore, most of the CS programs in KSA are working to meet the same set of SOs. Since CS programs are working to meet the same SOs, therefore, CLOs should be very similar for those programs. Fig. 3 illustrates how the CS courses for the CS programs must contribute towards the achievements of the same set of student outcomes (ABET a-k). it is expected that most of the CLOs especially in the core courses should be very similar because they are contributing to the same program outcomes.

The ABET a-k SOs are written in very broad and abstract statements that have been proven to be very difficult to be understood by the faculty within the same department. Therefore, it is very important to describe the ABET SOs in more specific measurable learning outcomes that describe what skills and knowledge students should exhibit in order to demonstrate the attainment of ABET a-k SOs. Here is where the CLOs of all courses must be developed to support the attainment of SOs.

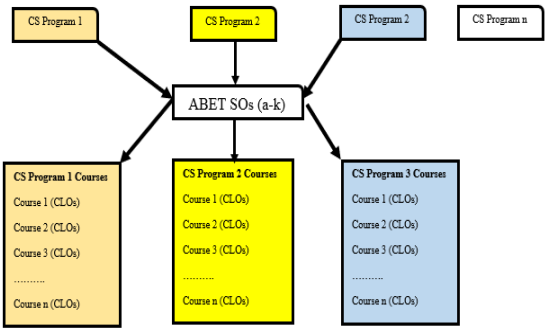

Fig. 3 Alignment of CS Programs to the CS ABET SOs

Table 1 shows some of the main knowledge areas in ACM and ABET along with their core courses in the CS program in Saudi universities.

Table 1: ACM and ABET along with the core courses of the CS program.

ACM	ABET	CS Core Courses
Programming Languages	Programming Languages	Object Oriented Programming
Data Structures and Algorithms	Data Structures and Algorithms	Data Structure and Algorithms
Operating Systems and Architecture	Computer Organization and Architecture	Computer Organization and Architecture
Information Management	Information Management	Fundamentals of Databases

An extensive research and review of the literatures was performed to define the main criteria of good CLO. The following criteria were defined and applied to create the ideal CLOs:

- One measurable action verb per CLO.
- Avoid vague and abstract action verb.
- Each CLO must have an action verb, subject content and criterion for achievement.
- Number of CLOs per course should be manageable (e.g. 8-15)
- Level of learning is suitable to the course topics and descriptions.
- CLOs must be achievable and assessable.

Table 2 shows the structure of a good CLO. The description of each component is also mentioned. An example of good CLO is shown in Table 2.

Table 2: CLO Structure, Description and example of good CLO

Action Verb	Subject Content	Criterion or standard

What the learner is expected to be able to do/know	describes the focus of the learning (indicate what the learner is acting);	A statement of the criterion or standard for an acceptable performance. (Words indicate the nature of the performance as evidence that the learning was achieved)
write an	APA style research paper	of 2500 words in length.

Figure 4 shows the internal machine learning engine including the sequence of processes to compare the quality of new unseen CLOs against a set of ideal CLOs. At the startup, the IDEAL CLOs are received by the dependency parser [28] that recognizes the words of the CLOs and their dependencies. In other words, it figures out the action verb and the subject content and criterion of the CLOs. The outputs of the dependency parser are received by the word embedding model conceptNet [29] to find similar words (action verbs, subject contents and criteria) for our identified action verbs, contents and criteria. Step 3 in Figure 4 shows the development of our decision tree based on the dependencies identified by the dependency parser and wording embedding model [30]. The weights on the decision tree are updated by using multiple IDEAL CLOs examples in our training set.

The testing CLOs are then received by the dependency parser (Step 4) and the wording embedding model (Step 5) in order to build the decision tree for the testing CLOs (Step 6). Then, a comparison between the decision tree of the new unseen CLOs (testing CLOs) and the decision tree that represents the ideal CLOs is made to assess the quality of the testing CLOs. The end result will be a percentage that describes the similarities between the testing CLOs and the IDEAL CLOs. The machine learning engine has been implemented.

Fig. 5 shows the architecture of the cloud-internet based approach that will use our proposed machine learning engine to measure the quality of CLOs over the internet. Below are the main steps to use the machine learning engine over the cloud:

- Build a decision tree of the ideal CLOs (See Fig. 4) and store it in the cloud (See Fig. 5).
- CLOs are sent from universities to the cloud.
- Build a decision tree for the received new CLOs.
- Compare the decision tree of the new unseen CLOs with the decision tree of the IDEAL CLOs.
- The server sends the percentage of similarities between the new (testing) unseen CLOs and the ideal CLOs to the corresponding university.

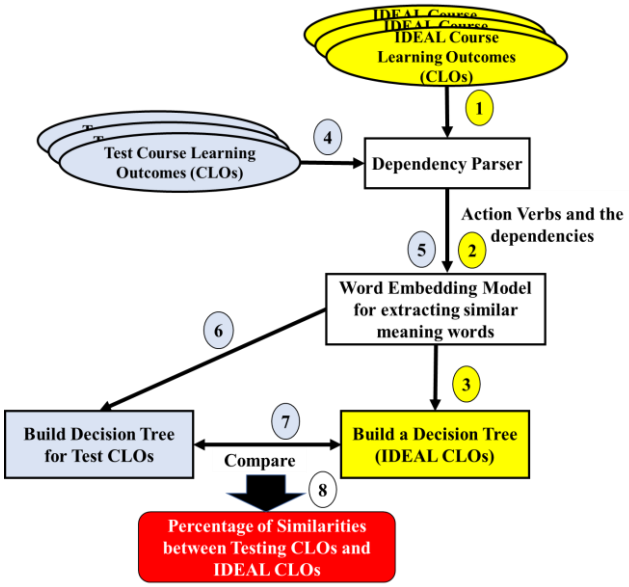

Fig. 4 Machine learning engine to assess the quality of CLOs

6. Results

Using the aforementioned guidelines and criteria for setting good CLOs, five senior faculty members from the computer science major established the IDEAL CLOs of four core courses in the CS major. The IDEAL CLOs of the following courses were established (1) Object Oriented Programming, (2) Data Structures and Algorithms, (3) Computer Organization and Architecture, and (4) Fundamentals of Databases. We collected the CLOs of four core courses from five different universities in Saudi Arabia as mentioned in Table 2. The dependency parser and word embedding model are used to build the decision trees of the ideal CLOS of four courses (mentioned in Table 2).

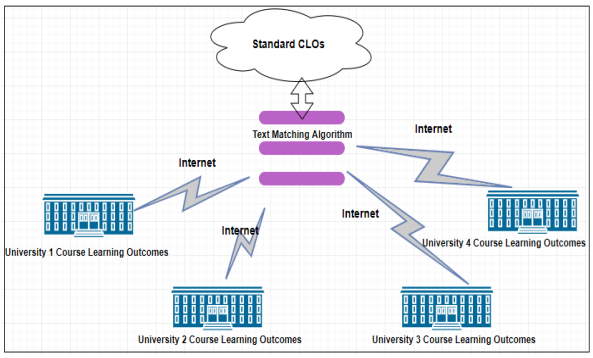

Fig. 5: Proposed Cloud-Internet Based Approach

The CLOs of the core courses from different universities were collected and sent to the machine learning engine to compare them with the IDEAL CLOs. Table 2 and Fig. 6

show the percentage of similarities. The target of 90% . In other words, if the percentage of similarities between the received CLOs and the standard (IDEAL) CLOs is below 90%, it means major changes must be taken by the university to improve the quality of the CLOs. We have tested this approach using collected data from five universities and found the following results. It is noted that the CLOs of King Saud University (KSU) are closer to the ideal CLOs. Whereas, the CLOs of King Faisal University (KFU) and King Khalid University (KKU) need to be improved. For KFUPM, two courses are above the target and two are below.

Table 2: Tested Results using our machine learning engine

KSA Universities→ **CS Core Courses**	*King Abdul-Aziz University (KAU)*	*King Saud University (KSU)*	*King Fahad University for Petroleum and Minerals (KFUPM)*	*King Khalid University (KKU)*	*King Faisal University (KFU)*
Object Oriented Programming	**85%**	95%	**85%**	**79%**	**87%**
Data Structures and Algorithms	**78%**	90%	92%	**77%**	**82%**
Fundamentals of Databases	94%	95%	**85%**	**83%**	**89%**
Computer Organization and Architecture	**88%**	**89%**	94%	**87%**	**75%**

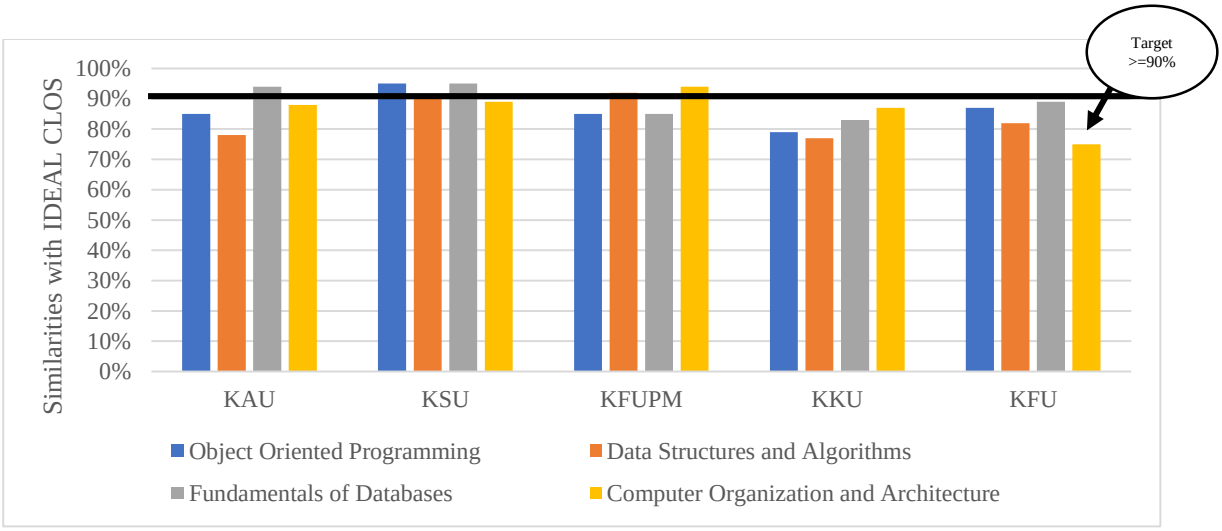

Fig. 5 Tested Results

7. Conclusion and Future Work

The proposed approach is based on machine learning methods to evaluate the quality and compatibility of CLOs against a well-defined CLOs that meet the international and national criteria. A set of CLOs for four core courses in the computing field have been established according the best criteria. These CLOs have been converted into the appropriate decision trees. Using the proposed machine learning engine including the dependency parser and word embedding model, the quality of new CLOs was evaluated and measured. Our approach was implemented and tested and showed a very impressive results in evaluating the quality of the new unseen CLOs.

In the future, we will test our approach over the cloud and measure the quality of more CLOs from different disciplines.

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