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Course Learning Outcomes Assessment (CLOs) using goals methods: case study of Aljouf University

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ABSTRACT:
This research study is inscribed in cycle improvement of training and academic programs for graduates at Aljouf University. So, in this paper, we show how to evaluate academic programs using the goals modeling to assess the course learning outcomes in this university. The academic program evaluation is a complex and multidisciplinary process. It relies on the technical process (requirement engineering that we use in computer and software engineering) and on other human science activities. Here, we are only interested in the technical aspect of this process. In this study, we use the goal model like it is used by the requirement engineering methods, such as goals-based requirement analysis method (GBRAM), I*, and collaborative requirement engineering with scenarios (CREWS) to identify the expected outcomes on the courses. As a result, the model that we present here feeds well the process of Course Learning Outcomes (CLOs). To experiment with our approach and model, we present the application of this evaluation process that is conducted at Al-Jouf University, in the department of computer sciences.

Keywords: Goals method, requirement engineering, Course learning outcomes assessment, Aljouf University.

Introduction:
Objective-based education has become a cornerstone of modern university training systems (Den Akker, 2006). The goal is to align educational programs with the precise demands of the labor market, ensuring that graduates are equipped with the skills and knowledge needed for their professional futures. Traditionally, this alignment is achieved through a two-phase process: upstream, identifying explicit labor market requirements, and downstream, defining the courses to be delivered during the training cycle. However, this classical approach often fails to keep pace with the rapidly evolving needs of the labor market, resulting in mismatches between graduate profiles and employer expectations.

To address this issue, this paper introduces a novel contribution by proposing a dynamic model for course content development, guided by the overarching “GOAL” that encapsulates labor market demands. Central to our approach is the use of goal modeling to evaluate Courses

Learning Outcomes (CLOs) against the target profiles expected by employers. For this, we adopt the "Goal Model," a framework often employed in requirement engineering methodologies such as GBRAM (Anton, 1996). This model allows us to effectively articulate and validate CLOs, ensuring they align with the desired labor market outcomes. Additionally, we introduce a CLOs evaluation table to quantify the extent to which goals are achieved.

This research is part of the broader effort to enhance the formulation of academic course reports, focusing specifically on the outcomes of course offerings. The study is grounded in a case study conducted at Aljouf University in Saudi Arabia, where faculty members assessed Learning Course Outcomes (LCOs) using our proposed framework.

Incorporating security and privacy considerations is vital in the digital age, particularly as higher education increasingly relies on information systems to manage and assess academic outcomes. Goal-based methodologies, such as the one we propose, involve the collection, analysis, and sharing of sensitive data, including academic performance metrics, course designs, and labor market analytics. Ensuring the security and privacy of this data is critical to maintaining trust and compliance with legal and ethical standards (AlShaikh, 2024).

Our approach emphasizes the protection of information integrity, confidentiality, and accessibility throughout the CLOs evaluation process. By integrating robust data security measures, such as encryption, access controls, and compliance with privacy frameworks (e.g., GDPR or national privacy laws), we ensure that sensitive information related to students, faculty, and institutional performance remains secure. Furthermore, protecting the application of this goal-based system from external threats, such as unauthorized access or data breaches, safeguards the credibility of the assessment outcomes and ensures the system's sustainability (Medileh, 2023; Kebache, 2023).

In this paper, we demonstrate how the combination of goal modeling and secure information management can optimize the alignment between educational outcomes and labor market expectations while maintaining the privacy and security of the information involved. The paper is structured into three sections: following this introduction, the first section delves into the theoretical framework and the role of goal modeling in CLOs evaluation. The second section presents the methodology, including the case study conducted at Aljouf University, and the third section concludes with the results, implications, and recommendations for future work.

The paper is structured as follows: after this introduction, we deliver a global overview of educational engineering and requirement engineering research field, based on one goal-based method, where we were interested in the used goal's model. Then, we present our main contribution: the process of Course Learning Outcomes Assessment. For experimentation, we give an example of CLOs with indicators that we teach in the computer engineer training at Aljouf University. The paper ends with a conclusion.

2. Related works

2.1 Educational Engineering

Educational engineering aims to improve the quality of education and professional training. It is a very old field of research in the humanities and techniques (Hoover, 1941), (Charters, 1945), but it is still a topical field (Laurillard, 2012), (Isaev, 2017).In the literature of this research field, we are interested in the different methodological processes. It consists of the framework for the majority of scientific research in educational engineering (fig. 1).

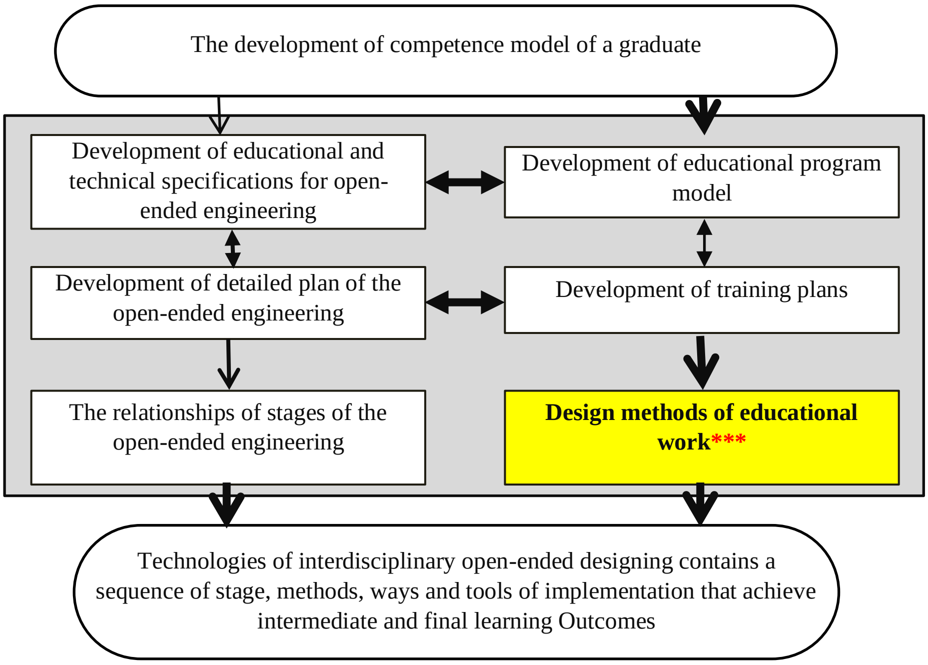

Fig. 1 The framework of research work in educational engineering

Our research is inscribed in design methods of educational work, or, it consists of proposing an approach for program learning outcomes assessment based on goals modeling which is the purpose of software engineering research works. Our target is to improve the quality of academic training programs at Aljouf University.

2.2 Requirement Engineering and Goals modeling methods

Steave Easterbrook defines 'Requirements Engineering' (RE) as a set of activities concerned with identifying and communicating the purpose of a software-intensive system and the contexts in which it will be used. Hence, requirements engineering acts as the bridge between the real world (real-world) needs of users, customers, and other constituencies affected by a software system, and the capabilities and opportunities afforded by software-intensive technologies (Easterbrook, 2004). Several research studies have marked this field of research (Loucopoulos, 1995), (Brunet, 2007), (Rolland, 2003), (Kavakli, 2002), (Lamsweerde, 2000), (Ross, 1977). It consists of a research domain that proposes concepts, processes, methods, and support tools that allow converting the needs of users (that are generally expressed as goals) to a model or part of the system/process to be built. So, the concept of "Goal" is always the kernel of this discipline. For us, the "Goal" in "educational engineering" is the main concept that we developed in this research. It is the element to be assessed by the course learning that we always define by the question "Why this chapter/element of the course?" We have also studied the proposed methods of this discipline that we grouped into three great classes.

– Goal-based methods: are characterized by the link between actors and processes. For the achievement of the goals, it is generally carried out by the temporal logic (Yu, 1998), (Lamsweerde, 1998), (Bubenko, 1994);

– Scenario-based methods: they show the particular situations of the requirement, drive conceptual models from scenarios and allow reasoning about the choice of designs (Caroll, 1995), (Potts, 1997), (Dano, 1997), (Jacobson, 1999);

- Mixed methods: They use the <goal, scenario> couple to define a fragment of requirement (Tawbi, 2001), (Rolland, 2003).
-

As a result, the study of a goal-based method was essential for this research. And seeing its popularity, we have chosen the GBRAM method.

GBRAM - Goals-Based Requirement Engineering Analysis Method

GBRAM is a goal-based requirement analysis method. It carries out two processes: goals analysis and goals evolution. For the first process, the work consists of the analysis of different goals and their document as they are expressed in each level of organization. Then, for each goal, we describe the different steps of its evolution until its achievement. This method uses a set of concepts: goal, requirement, operationalization, achieved goal, maintaining goal, agent, constraint, goal decomposition, and goal obstacle. We were interested by the concept “Goal” in this method because it coincides well with our occupation that consists of assessing of course learning outcomes. So we have developed the model of goal that uses GBRAM – the most useful model of goal –.

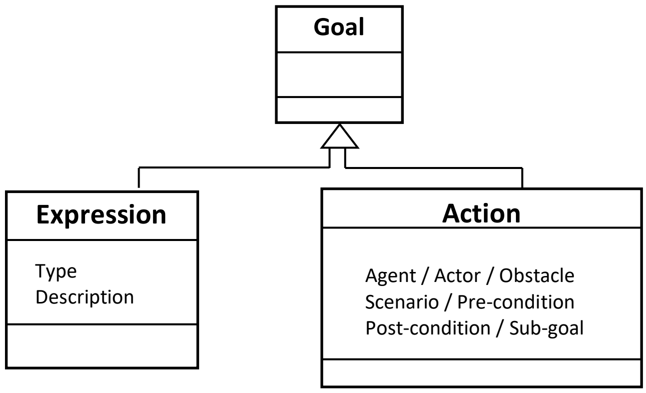

Fig.2 Goal’s model of GBRAM

The model that we presented below may be reformulated by the following linguistic structure:
Goal= [{<Expression>, <Type>, <Description>}, {<Action>, <Agent>, <Actor>, <Obstacle>, <Scenario>, <Pre-condition>, <Post-condition>, <Sub-goal >}]

The choice of GBRAM method is imposed in this research because of two reasons: First (upstream of an academic program): in educational engineering, to provide training according to the demand of the labor market, the programs and the content of the course are developed on the basis of the expressed requirements of the labor market which formulate in the form of a list of "goals". The goal of a program is a set of sub-goals (the sub-goal of a program is a goal of one of its courses). Secondly (downstream of an academic program): the learning program assessment aims to measure the rate of achievement of the "goals" of each course (CLOs Assessment), which feeds the battle horse of this research. So using the concept of "goal", it is easy to convert the result of CLOs to quantitative measures.

3. Our approach of CLOs assessment

The proposed approach of CLOs assessment articulates three steps. Each step uses a specific model, template and/or table (Fig. 3). In the beginning, we express the goal of the academic program (PG) around of five axes that are called learning domains (Knowledge – Cognitive Skills- Interpersonal Skills and responsibilities, communication & information technologies, Psychomotor skills). And for each learning program domain (LPD), we express its expected results that we call LPOs). So, the requirement of the program is expressed as a couple (GP – LPs).

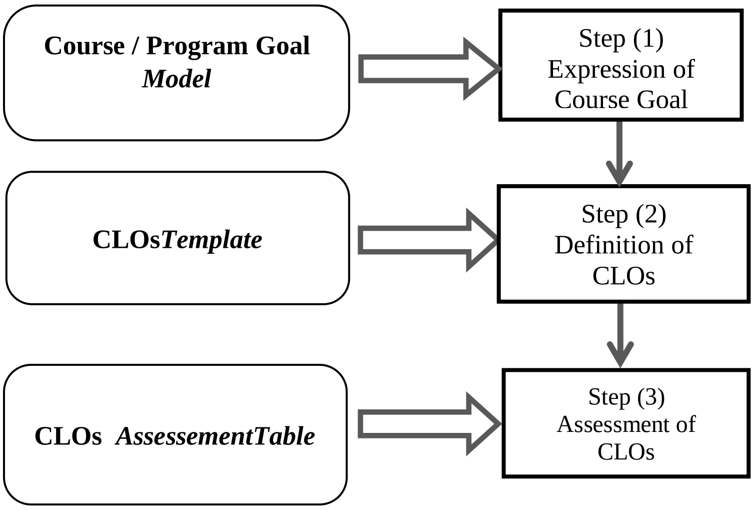

Fig. 3 Global overview of CLOs Assessment Approach

We recall that the program and course are expressed using the same model of goal, but the different that we must underline is the level of detail. Or, the course is more detailed than the program.

- PG = PLDs + LPOs
- CG = CLDs + CLOs

3.1 Expression of Course Goal

Model of Goal in Course Learning Outcomes

Based on the PLOs that we analyze, we get a list of sub-goals that express the goals of courses (CG). Each program sub-goal or (CG) is also expressed in the five learning domains that we above listed. Then, we obtain the list of course-like goals to which we will assign a set of results that we call Course Learning Outcomes – CLOs). In this paper, we will not present the mechanisms of goals program decomposition to get the course goals, because it comes from another discipline (educational engineering). We only will be limited to the course goals and the assessment of their outcomes (assessment CLOs) according to the fixed scale.

We formalize the CG with the following way (Fig. 4):

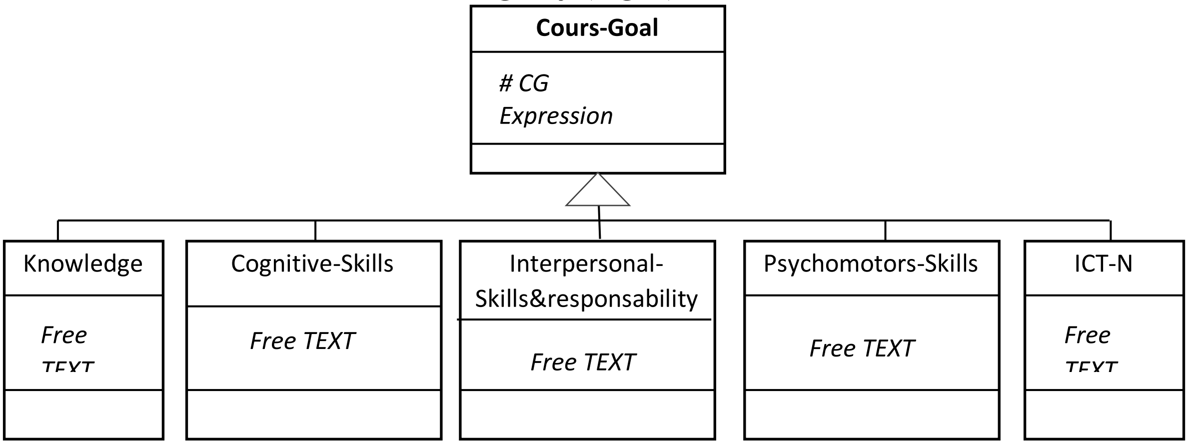

Fig.4 Couse's Goal model with UML annotation

The course goal expresses a global overview as a free text of the five learning domains of the course.

3.2 Definition of Course Learning Outcomes

The course goal (CG) is expressed by five learning domains:
CG = {{Knowledge}, {Cognitive Skills}, {Interpersonal Skills & Responsibility}, {ICT & numeric}, {Psychomotor Skills}}.
The result expected by each learning domain defines the course learning outcomes (CLOs).
The next table (Table 1) presents a global canvas of CLOs. We have filled it exampling with Undergraduate Learning Outcomes – University of California at Santa Barbara Students graduating with a B.A. or B.S. in Physics –. So, the table shows what students should be able to do.

Table 1 Canvas of CLOs expression

Learning Domains	Learning Outcomes	Do	Don't
Knowledge	Apply basic mathematical tools commonly used in physics, including elementary probability theory, differential and integral calculus, vector calculus, ordinary differential equations, partial differential equations, and linear algebra.	✓	
	Apply the basic laws of physics in the areas of classical mechanics, Newtonian gravitation, special relativity, electromagnetism, geometrical and physical optics, quantum mechanics, thermodynamics and statistical mechanics.	✓	
Cognitive Skills	Apply more advanced mathematical tools, including Fourier series and transforms, abstract linear algebra, and functions of a complex variable.	✓	
	Use classic experimental techniques and modern measurement technology, including analog electronics, computer data acquisition, laboratory test equipment, optics, lasers, and detectors.	✓	
	Exercise the use of physical intuition, including the ability to guess an approximate or conceptual answer to a physics problem and recognize whether or not the result of a calculation makes physical sense.	✓	
	Recognize how observation, experiment and theory work together to continue to expand the frontiers of knowledge of the physical universe.	✓	
Interpersonal Skills & Responsibility	Communicate verbally, graphically, and/or in writing the results of theoretical calculations and laboratory experiments in a clear and concise manner that incorporates the stylistic conventions used by physicists worldwide.	✓	

	Convert a physical situation articulated in English to a mathematical formulation, and then analyze it quantitatively.	✓	
Communication, Information Technology, Numerical	Access information on a topic from a variety of sources, and be able to learn new things on one’s own.	✓	
	Use basic laboratory data analysis techniques, including distinguishing statistical and systematic errors, propagating errors, and representing data graphically.	✓	
Psychomotor Skills	Collecting and analyzing appropriate data.	✓	
	Using of methods, tools, and instruments.	✓	
	Practicing routine methods of enquiry, investigation and research for a defined project	✓	
	Communicating in writing appropriately and effectively.	✓	
	Communicating verbally appropriately and effectively.	✓	

For CLOs expressing, we use the list of standard statement that are used in educational engineering (Benjamin, 1956), (Table 2):

Table 2 List of learning verbs

Know	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Define	Articulate*	Act	Analyze	Appraise	Adapt
Identify	Characterize	Administer	Arrange*	Argue	Anticipate
Inventory*	Cite	Apply	Break!down	Assess	Arrange*
List	examples	Articulate*	Calculate	Choose	Assemble
Locate*	Describe	Choose	Categorize	Compare	Collect
Name	Diagram*	Compute	Compare	Conclude	/Combine
Recall	Discuss	Control	Contrast	Critique	Compose
Record	Explain	Demonstrate	Correlate	Determine	Construct
Repeat	Express	Dramatize	Debate	Diagnose*	Create/
Restate*	Interpret	Employ	Deduce Detect	Estimate	Design
State	Outline*	Generalize	Determine	Evaluate	Devise/
Underline	Paraphrase	Illustrate	Diagnose*	Judge	Develop
	Report	Imitate	Differentiate	Justify	Diagram*
	Respond	Implement	Distinguish	Measure	Formulate
	Restate*	Instruct	Discriminate	Prioritize	Generate
	Review	Interview	Examine	Rate	Initiate
	Translate	Operate	Inspect	/Revise	Integrate Invent
		Perform*	Inventory*	Score	Model / Modify
		Practice	Locate*	Select	Negotiate / Plan
		Select	Outline*	Support	Perform*
		Simulate	Question	alidate	Predict
		/Use	Relate	Value/	Prepare
		Utilize	Separate	Test	Produce
			Subdivide		Propose
					Reconstruct
					Substitute
					Synthesize

Here, we made in bold polices only the measurable verbs that we generally use in educational engineering.

3.3 Assessment of CLOs

The value of each sub-goal (total of achieved grades) is the average of the grades of students according to a fixed scale of a learning domain.

Table 3 Model of the table of CLOs assessment

Domaine of Learning		**Total of achieved grades**	**Total / 100**	**Percentage**
Code	**ITEM**			
1	Knowledge	G_1	S_1	G_1 / S_1 (%)
2	Cognitive Skills	G_2	S_2	G_2 / S_2 (%)
3	Interpersonal Skills & Responsibility	G_3	S_3	G_3 / S_3 (%)
4	TIC and Numeric	G_4	S_4	G_4 / S_4 (%)
5	Psychomotor Skills	G_5	S_5	G_5 / S_5 (%)
Total		Achieved Total (AT)	100	AT %

- S_i: fixed scale for learning domain;
- AT $=\sum_{n=1}^{nbr-LD} G_i$: achieved total;
- G_i = the average of the students grade in a learning domain.

The PLOs assessment is obtained by consolidating of all CLOs assessment.
In this paper, we present only the assessment of Information technologies course.

4. Experimentation

We have carried out our approach at Al-Jouf University. We were interested in the department of Computer Science and the Unit of Quality and Academic Accreditation. After working on the documents that we got, we remarked that the computer engineering program aims “to prepare students for careers that deal with computer and networks engineering who are able to contribute to the continued advancement in computer and networks engineering in order to serve to local, and regional communities while maintaining the quality assurance standards (local and international)”.

This text consists of the first goal of the program that we discovered and elicited in the beginning. This goal will be detailed into sub-goals and will define the program learning outcomes (Table 4).

4.1 Expressing of course goal

Before expressing course goals, we must know in which program the courses will be given to students. So, in the beginning, we take to express the goals of a computer engineering program at Al-Jouf University:

Table 4 Example of Goal Program (computer and Network engineering – Al-Jouf University)

Program Learning Goals	**Program Learning Outcomes - PLOs**
"Computer engineering graduates will be prepared to compete in the global engineering market".	1: Students will be provided with the basic concepts of science, mathematics, computation, and engineering to successfully apply them in their chosen endeavors.
	2: Students will be provided with knowledge and skills essential to engineering processes, including design, analysis, synthesis, fabrication, and experimental techniques.
	3: Students will be prepared for professional interaction and leadership including multi-disciplinary collaboration, and effective oral and written communication.
	4: Students will understand their professional and ethical responsibilities.
	5: Students will understand technology within a global. Societal and economic context.
	6: Students will be prepared for lifelong learning

Basing on analysis of the program learning outcomes that are presented in Table 4, we conclude that these goals are achieved by teaching the following courses (Table 5).

Table 5 Couse's Goal 'IT 101 Information technologies'

Level 1		**Level 2**	
# Course	**Label**	**# Course**	**Label**
ARAB 101	Linguistic Skills	CSC 102 ENGL 102 IC 100 MATH101 STAT104	Computer Programing Writing Skills Introduction to Islamic cultures Introduction to Diff Calculating Principles of Stat and Proba
COMM101	Communication and high studies Skills		
ENGL100	English 1		
IT 101	**Information Technologies**		
MATH100	Math 1		
Level 3		**Level 4**	
ARAB 103 CSC 104 CSC 316 ENGL 123 IC 102 MATH112	Arabic redacting Computer Programing Computer and society Listening Skills Islam and society building Integral Calculating	CSC 216 CSC 217 CSC 225 ENGL 124 IC 103 MATH231	Logical designing Data structures Computing organization -society Ling Translating in computer studies field Islamic Economic system

			Calculating of integrals and differential
Level 5		**Level 6**	
CSC 353	Operating systems	CSC 325	Databases
CSC 337	Principles of programing languages	CSC 328	Computer building
CSC 351	Management of computer center	CSC 343	Software engineering
CSC 383	Date Structure	CSC 363	Artificial intelligence
IC 105	Principles of human rights	CSC 375	Human and machine interaction
MATH242	Laniary Algebra	OPER 201	Operational research
Level 7		**Level 8**	
CSC 338	Ontologies designing	CSC 403	Internet technologies
CSC 422	Computer network systems	CSC 413	Algorithms analysis & designing
CSC 426	Advanced databases	CSC 491	Selected topics (2)
CSC 447	Management of programing projects	CSC 492	Distributing Sys and Prall. Process
CSC 490	Selected topics (1)	CSC 495	Research project (2)
CSC 494	Research project (1)		

Here, we describe only the goal of the course 'Information Technologies' as it is taught at Aljouf University in 'Computer engineering' program, during the academic year: 2018/2019.

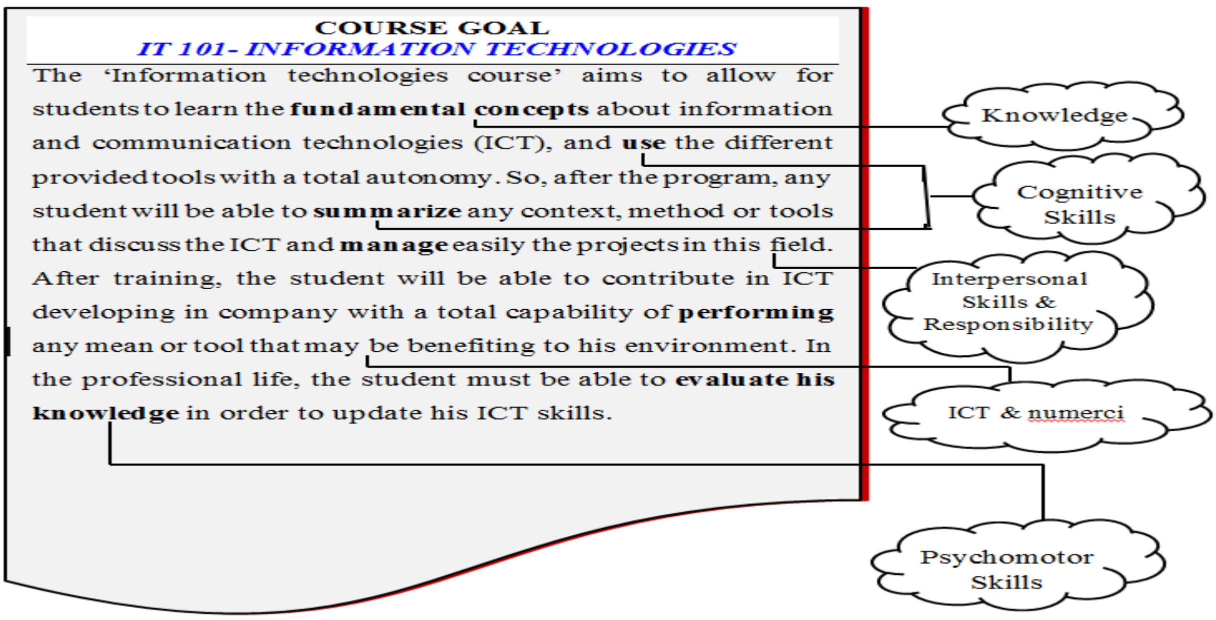

Fig 5 Course's Goal 'Information Technologies'

4.2 Definition of CLOs

We get the list of CLOs based on goal course analysis. In this step, we are supported by the use of the verbs list that express the learning statement as they are proposed in Table 2 (below), by Benjamin Bloom[3]. This step is the most difficult stage of our approach because the faculty

[3]**Benjamin Samuel Bloom** (1913 - 1999) is an American educational psychologist who made contributions to the

member who uses this approach must have good experience in educational engineering. In order to simplify reading, we present in this experimentation, only one-course learning outcome (CLO) by course learning domain (CLD) of "information technologies" as it is assessed, because in fact, each CLD may group more than one CLO.

Table 6 Table of courses learning outcomes ("Information technologies" – Aljouf University)

CLD	CLOs
Knowledge	**Acquire** and learn different concepts (MIT, ARPA, ARPANET, INTERNET, HTML, XML, WWW, http, htpps, ftp, FAQ, CHAT) and IT tools (email, FAQ, Forum, broadcasting tool, social network).
Cognitive Skills	**Use** the all of ICT tools with a total autonomy.
Interpersonal Skills & Responsibility	**Summarize** content of IT concept and tools; **Manage** any ICT Project.
TIC and Numeric	**Perform** any ICT mean or tool in a company.
Psychomotor Skills	**Evaluate** acquired knowledges.

4.3 Course Learning Outcomes assessment

The task consists in average calculating of the grades of students in different examinations, and their distribution on the five learning domains. The result is presented in Table 7.

Table 7 Table of grades distributing of students according to the Learning Model "Course: Information Technologies"

CLD	CLOs	Assignments	Midterm Exam	Exercises	Final Exam	Total of achieved grades
Knowledge	**Acquire** and learn different concepts (MIT, ARPA, ARPANET, INTERNET, HTML, XML, WWW, HTTP, HTTPS, FTP, FAQ, CHAT) and IT tools (email, FAQ, Forum, broadcasting tool, social network).	1	5	2	8	16
Cognitive Skills	**Use** the all of ICT tools with total autonomy	2	5	1	10	18
Interpersonal Skills & Responsibility	**Summarize** the content of IT concepts and tools; **Manage** any ICT Project.	2	6	2	8	18

classification of educational objectives and to the theory of mastery learning.

TIC and Numeric	**Perform** any ICT means or tool in a company.	2	4	1	6	13
Psychomotor Skills	**Evaluate** acquired knowledge.	2	3	1	7	13
Total		10	30	10	50	100

At the end, the assessment is a simple comparison operation between the fixed total to the achieved result of each learning domain.

Table 8 Table of CLOs Assessment of “Information Technologies Course”

Course Learning Domain	**CLOs**	**Total of achieved grades**	**Total**	**Achievement in Percent %**
Knowledge	Acquire and learn different concepts (MIT, ARPA, ARPANET, INTERNET, HTML, XML, WWW, HTTP, HTTPS, FTP, FAQ, CHAT) and IT tools (email, FAQ, Forum, broadcasting tool, social network).	14	20	70
Cognitive Skills	Use the all of ICT tools with total autonomy	12	22	54.54
Interpersonal Skills & Responsibility	Summarize content of IT concepts and tools and Manage any ICT Project.	9	16	56.25
TIC and Nummeans	Perform any ICT mean or tool in a company.	13	22	59.09
Psychomotor Skills	Evaluate acquired knowledge.	10	20	50
Totals		**58**	**100**	**58**

The following graphic illustrates the achieved percentage of each learning domain.

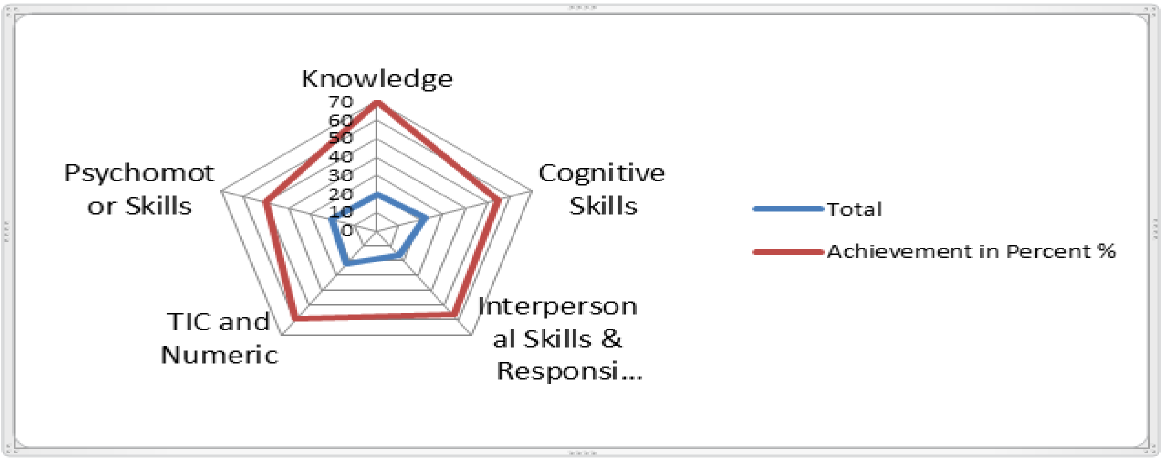

Fig. 6 Percentage of achieved total on learning domain

Comment:
The knowledge acquisition is the most part of the achieved Information technologies course goal because it groups the easier chapter of this course. However, psychomotor skills take the last place in this distribution of the achieved goal rate because it need more experience with the use of ICT in a professional environment. The following graphic presents the distribution of the achieved total of LCOs.

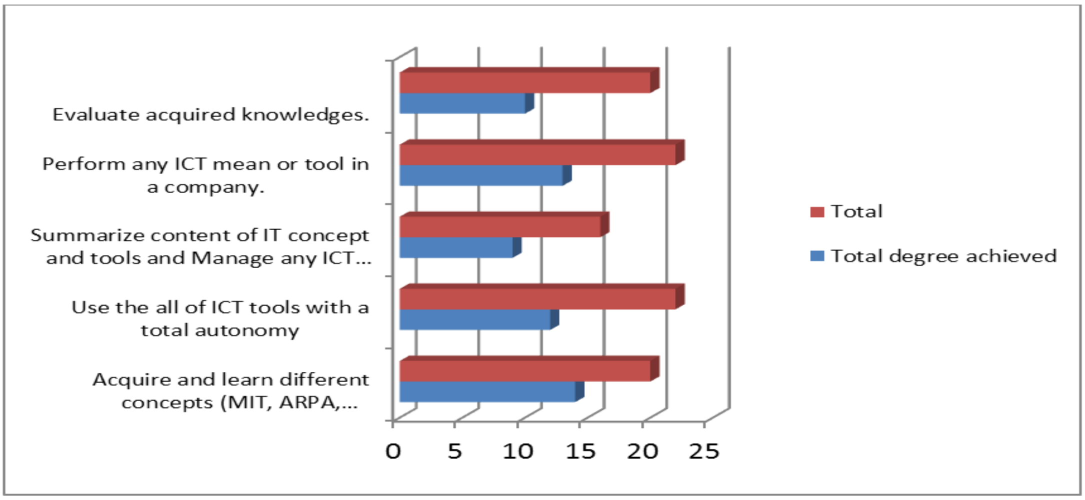

Fig. 7 Repartition of achieved CLOs than a fixed total

Comment: the achieved scores of CLOs are more than the average. And the goal of this course is achieved at 58%. So, we say that this course interests well the students of the computer engineering program.

5. Conclusion

The evaluation of academic programs is the vocation of educational engineering, which consists of defining the programs according to the labor market requirements. The practices in this area still have limitations and shortcomings because of the labor market needs that are changing during the elaboration or updating of academic programs. This is the axe to which our approach contributes. It helps better the academicians in evaluating the results of their courses when the faculty members are assessing the program outcomes. In this paper, we defined an approach for course assessment using goal modeling as it is used in requirements engineering.

Our approach allows us to:
- Express the goal of the course;
- Define the course outcomes that it is expected to feed well a program;
- Fix the course learning outcomes in order to assess it as well as possible;

In our approach, we have proposed a process for academic program analysis to accord it well with the needs of the labor market. This process exploits:

- A Course Goal Model to express the requirement of a course in a program;
- A Learning Outcomes Model for program evaluation;
- An assessment table for course learning outcomes.

Our approach is experimented with at Al-Jouf University in accordance with the guidelines that are proposed by the National Commission for Academic Accreditation & Assessment in the Kingdom of Saudi Arabia (NCAAA, 2011). We have assessed the course outcomes of the Computer Engineering Program as it is provided at Al-Jouf University during the first semester of the 2018-2019 academic year. We found a very favorable echo to use our approach by the faculty members. As the rest of this research, we proposed to detail more the mechanisms of academic programs analysis according to the requirements of the labor market.

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