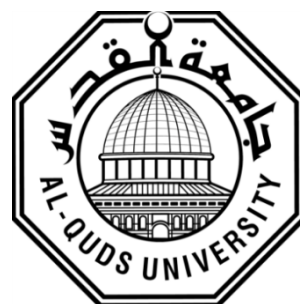


**Deanship of Graduate Studies**

**Al-Quds University**



**Dynamic Learning Profile (DLP) based on Achieved  
Learning Outcomes**

**Baha “Mohammad Ghalib” Khader Thabet**

**M.Sc. Thesis**

**Jerusalem-Palestine**

**1438 / 2017**

# **Dynamic Learning Profile (DLP) based on Achieved Learning Outcomes**

**Prepared By:**

**Baha “Mohammad Ghaleb” Thabet**

**B.Sc. Computer Science from An- Najah National  
University- Palestine.**

**Supervisor: Dr. Badie Sartawi**

**A Thesis Submitted in Partial Fulfillment of the  
Requirements for the Degree of Master of Science in  
Computer Science /Department of Computer Science  
Faculty of Science &Technology /Deanship of Graduate  
Studies /Al-Quds University.**

**1438/2017**

**Deanship of Graduate Studies**

**Al-Quds University**

**Computer Science**



**Thesis Approval**

This thesis is approved for recommendation to the Graduate Council.

**Prepared by:** Baha 'Mohammad Ghaleb' Thabet

**Student ID No:** 21210157

**Supervisors:** Dr. Badie Sartawi

**Master thesis submission and acceptance date:** 27/ 04/ 2017

**The names and signatures of examining committee members are as**

**Follows:**

1. Head of committee: Dr. Badie Sartawi

Signature.....*Badie Sartawi*

2. Internal Examiner: Dr. Kamel Hashem

Signature.....*Kamel Hashem*

3. External Examiner: Dr. Fatima Hallak

Signature.....*Fatima Hallak*

**Jerusalem-Palestine**

**1438/2017**

## **Dedication**

I dedicate my thesis to my family. A special feeling of gratitude to my loving parents, whose words of encouragement and push for tenacity ring in my ears. And for my parents in law, who have never left my side and are very special. I also dedicate this dissertation to my beloved wife and my wonderful kids, and I will always appreciate their patience, encouragement and all they have done for me. I also dedicate this dissertation to my brothers and sisters who have supported me throughout the process.

Thank you all

**Baha ‘Mohammad Ghaleb’ Thabet**

### **Declaration**

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis or any part of the same has not been submitted for a higher degree to any other university or institution.

Signed:

A handwritten signature in blue ink, appearing to be 'Baha Thabet', written over a horizontal line.

Baha 'Mohammad Ghaleb' Thabet

Date: 27/ 04 / 2017

## **Acknowledgement**

First and foremost, I would like to thank my advisors, Dr. Badie Sartawi, Vice President for Research Development and Innovation and Dr. Jad Najjar from the CS & IT department. They have inspired and taught me since the days I began working on this thesis. I appreciate all their contributions of time, ideas and support to bring this work to the life. Also, I would like to thank my advisers and colleagues in the ILT research project, who have been the source for this work as well as good advice and collaboration.

Additionally, I would like to thank my committee members Dr. Kamel Hashem and Dr. Fatima Hallaq for their interest in my work.

In regards to Al-Quds Open University, I would like express my gratitude to professor Younis Amro, President, for giving me this chance to develop my academic career and supporting me during my study.

Finally, I would like to acknowledge friends and family who supported me during my time here. First and foremost, I would like to thank my parents and my parent-in-law for their constant love and support. Also, I owe a debt of gratitude to my wife for her patience and support and to all my sisters and brothers.

## **ABSTRACT**

Recently, learning personalization became an emerging trend to meet the learner's needs in the online learning environments. Great efforts and researches have been conducted previously to personalize learning and to enhance the learner experience in terms of the learning styles and the cognitive state for learners. The prior researchers tried to identify the learner needs according to the educational domains, and they used different methodologies for that purpose such as semantic web, questionnaires, and prediction. However, in this research, we have introduced a learning personalization model according to the learner achievements in the Learning Outcomes (LOs). Therefore, we designed and implemented the Dynamic Learning Profile (DLP) for evaluating, tracking and storing the learners' LO achievements based on the course formal assessments. The DLP model consists of three components: the LO Achievement Evaluation (LO-AE), the LO Achievement Tracking (LO-AT) and the LO Achievement Profile (LO-AP).

The DLP model is providing instructors and learners with a tangible way to deal and interact with the LOs. Therefore, they will be able to visualize the actual relationship between LOs, assessments and learner's performance. Therefore, learners will know and view their performance as achievement records linked with learning outcomes rather than it is only performance as averages or numbers. And they will have also the chance to look for other learning material to enhance their achievements. In DLP, learners also will have clear expectations on what they know and able to do, so that their achievement profile can be shared with employers and with other educational institutions.

For instructors and decision makers, the DLP model is providing the opportunity to analyze and study the LOs according to the learners' achievements to enhance the courses and the learning outcomes for the learners.

## TABLE OF CONTENTS

|                                                                    |            |
|--------------------------------------------------------------------|------------|
| <b>Declaration.....</b>                                            | <b>i</b>   |
| <b>Acknowledgement .....</b>                                       | <b>ii</b>  |
| <b>Abstract.....</b>                                               | <b>iii</b> |
| <b>LIST OF FIGURES .....</b>                                       | <b>vii</b> |
| <b>LIST OF Tables.....</b>                                         | <b>x</b>   |
| <b>1. Introduction .....</b>                                       | <b>1</b>   |
| 1.1 Introduction.....                                              | 1          |
| 1.2 Problem Statement .....                                        | 2          |
| 1.3 Research Questions .....                                       | 3          |
| 1.4 Objectives.....                                                | 4          |
| 1.5 Methodology .....                                              | 4          |
| <b>2. Related Works .....</b>                                      | <b>6</b>   |
| 2.1 Learning Personalization.....                                  | 6          |
| 2.2 Measuring Learning Outcome Achievements for Learners .....     | 9          |
| 2.3 Conclusion .....                                               | 11         |
| <b>3. DLP Model.....</b>                                           | <b>14</b>  |
| 3.1 DLP Overview .....                                             | 14         |
| 3.2 DLP Environment .....                                          | 15         |
| 3.3 DLP Components.....                                            | 16         |
| 3.3.1 LOs Achievements Profile (LO-AP).....                        | 17         |
| 3.3.2 Learning outcome Achievements Evaluation Model (LO-AE) ..... | 19         |
| 3.4.3 LO Achievements Tracking Module (LO-AT).....                 | 21         |
| <b>4. modeling and design.....</b>                                 | <b>23</b>  |
| 4.1 Methodology .....                                              | 23         |

|                                                    |           |
|----------------------------------------------------|-----------|
| 4.2 DLP Environment .....                          | 23        |
| 4.3 DLP Use Case .....                             | 24        |
| 4.4 LO-AE Design and Algorithms .....              | 27        |
| 4.4.1 LO-AE Schema Design.....                     | 27        |
| 4.4.2 LO-AE Algorithms .....                       | 29        |
| 4.5 LO-AP Design.....                              | 31        |
| 4.6 LO-AT Algorithms .....                         | 32        |
| 4.6.1 Initial State Algorithm (1).....             | 33        |
| 4.6.2 Course Enrollment State Algorithm (2) .....  | 33        |
| 4.6.3 Assessment Grading State Algorithm (3) ..... | 34        |
| 4.6.4 Ending Course State Algorithm (4) .....      | 35        |
| 4.7 DLP Schema .....                               | 36        |
| 4.7 DLP Architecture Layers .....                  | 38        |
| <b>5. DLP System Implementation .....</b>          | <b>40</b> |
| 5.1 Implementation .....                           | 40        |
| 5.2 Database Design and implementation.....        | 40        |
| 5.2.1 Entity Relationship Diagram (ER).....        | 40        |
| 5.3 User Interface .....                           | 42        |
| <b>6. Testing AND RESULTS .....</b>                | <b>46</b> |
| 6.1 Experiment.....                                | 46        |
| 6.2 Assessment Design Phase .....                  | 48        |
| 6.2.1 Course LOs Selection.....                    | 48        |
| 6.2.2 LOs Total Grades .....                       | 49        |
| 6.3 DLP Creation Phase .....                       | 54        |
| 6.3.1 DLP Initial State.....                       | 54        |

|                                     |           |
|-------------------------------------|-----------|
| 6.3.2 DLP in Grading State .....    | 55        |
| 6.4 LOs Achievements Results .....  | 72        |
| 6.5 Results and Analysis .....      | 72        |
| <b>7. Conclusions .....</b>         | <b>75</b> |
| 7.1 Summary and Contributions ..... | 75        |
| 7.2 Future Work .....               | 75        |
| <b>References .....</b>             | <b>77</b> |
| <b>80..... الملخص</b>               |           |

## LIST OF FIGURES

|                                                                              |    |
|------------------------------------------------------------------------------|----|
| Figure 1: DLP Architecture.....                                              | 15 |
| Figure 2: DLP Environment.....                                               | 16 |
| Figure 3: Activity Model for DLP .....                                       | 17 |
| Figure 4: PALO Schema .....                                                  | 18 |
| Figure 5: LO-AT Course States .....                                          | 22 |
| Figure 6: New Integrated System.....                                         | 24 |
| Figure 7: Use Case Model for DLP .....                                       | 25 |
| Figure 8: Activity Model for Setting-Up Course and Assessments in LO-AE..... | 26 |
| Figure 9: Class Model for LO-AE .....                                        | 28 |
| Figure 10: Activity Model for LO-AE Algorithm .....                          | 29 |
| Figure 11: Get Total LO Grade Weight Algorithm .....                         | 30 |
| Figure 12: Get Learner LO Achieved Grade by Assessment.....                  | 30 |
| Figure 13: LO-AP Class Diagram.....                                          | 32 |
| Figure 14: LO-AT Algorithm (1).....                                          | 33 |
| Figure 15: LO-AT Algorithm (2).....                                          | 34 |
| Figure 16: LO-AT Algorithm (3).....                                          | 35 |
| Figure 17: LO-AT Algorithm (4).....                                          | 35 |
| Figure 18: DLP Schema .....                                                  | 37 |
| Figure 19: The Architecture of DLP (Instructor View) .....                   | 38 |
| Figure 20: The Architecture of DLP (Student View) .....                      | 39 |
| Figure 21: Entity Relationship Diagram .....                                 | 42 |
| Figure 22: Courses Screen .....                                              | 43 |
| Figure 23: Course Learning Outcomes Screen .....                             | 43 |

|                                                                                     |    |
|-------------------------------------------------------------------------------------|----|
| Figure 24: Assessments Settings Screen .....                                        | 44 |
| Figure 25: Assessments Outcomes Screen.....                                         | 44 |
| Figure 26: Assessments Questions Screen.....                                        | 45 |
| Figure 27: Assessments Grading Sheet Screen.....                                    | 45 |
| Figure 28: DLP System, Assessment Creation Screens.....                             | 51 |
| Figure 29: DLP System, Aligning LOs to Assessments Screens.....                     | 52 |
| Figure 30: DLP System, Aligning LOs to Questions with scores Screens .....          | 53 |
| Figure 31: DLP System, Alaa DLP when she attended the course Data Transmission.     | 54 |
| Figure 32: DLP System, Madlin DLP when she has attended the course Biostatistics .  | 55 |
| Figure 33: DLP System, Grading Midterm, Final, and Project Exams respectively ..... | 56 |
| Figure 34: DLP System, Ahmed DLP and achievements after grading midterm exam        | 58 |
| Figure 35: DLP System, Ahmed DLP and achievements after grading final exam .....    | 59 |
| Figure 36: DLP System, Ahmed DLP and achievements after grading project .....       | 60 |
| Figure 37: DLP System, Ahmed Matrix Grades (LO, Exam, Grade).....                   | 60 |
| Figure 38: DLP System, Lia DLP and achievements after grading midterm exam.....     | 62 |
| Figure 39: DLP System, Lia DLP and achievements after grading final exam.....       | 63 |
| Figure 40: DLP System, Lia DLP and achievements after grading final exam.....       | 64 |
| Figure 41: DLP System, Lia Matrix Grades (LO, Exam, Grade) from the System.....     | 64 |
| Figure 42: DLP System, Grading Final and Project Exams respectively .....           | 65 |
| Figure 43: DLP System, AhmedDT DLP and achievements after grading final exam .      | 67 |
| Figure 44: DLP System, AhmedDT DLP and achievements after grading project.....      | 67 |
| Figure 45: DLP System, AhmedDT Matrix Grades (LO, Exam, Grade) .....                | 67 |
| Figure 46: DLP System, Alaa DLP and achievements after grading Final exam.....      | 68 |
| Figure 47: DLP System, Alaa DLP and achievements after grading project .....        | 69 |
| Figure 48: DLP System, Alaa Matrix Grades (LO, Exam, Grade) .....                   | 69 |

|                                                                                  |    |
|----------------------------------------------------------------------------------|----|
| Figure 49: DLP System, Grading Final Exam .....                                  | 70 |
| Figure 50: DLP System, Hanan DLP and achievements after grading final exam.....  | 70 |
| Figure 51: DLP System, Hanan Matrix Grades (LO, Exam, Grade) .....               | 71 |
| Figure 52: DLP System, Madlin DLP and achievements after grading final exam..... | 71 |
| Figure 53: DLP System, Madlin Matrix Grades (LO, Exam, Grade) .....              | 71 |

## LIST OF TABLES

|                                                                                                     |    |
|-----------------------------------------------------------------------------------------------------|----|
| Table 1: Assessment-CO Matrix.....                                                                  | 10 |
| Table 2: Assessment Distribution .....                                                              | 10 |
| Table 3: LO-AE Matrix for Assessment A1 .....                                                       | 20 |
| Table 4: LO-AE Matrix for all Assessments in the Course .....                                       | 20 |
| Table 5: Transitive Dependency Relations .....                                                      | 41 |
| Table 6: Computer Architecture and Organization Course, Students Result in all<br>Assessments ..... | 46 |
| Table 7: Data Transmission Course, Students Result in all Assessments .....                         | 47 |
| Table 8: Data Transmission Course, Students Result in all Assessments .....                         | 47 |
| Table 9: Course Learning Outcomes .....                                                             | 49 |
| Table 10: MS Excel, LO-AE Matrix.....                                                               | 50 |
| Table 11: MS Excel, Ahmed Achievements after each exam grading .....                                | 57 |
| Table 12: MS Excel, Lia Achievements after each exam grading .....                                  | 61 |
| Table 13: MS Excel, AhmedDT Achievements after each exam grading .....                              | 66 |
| Table 14: MS Excel, Alaa Achievements after each exam grading.....                                  | 68 |
| Table 15: MS Excel, Hanan Achievements after the exam grading .....                                 | 70 |
| Table 16: MS Excel, Madlin Achievements after the exam grading .....                                | 71 |
| Table 17: LOs Achievements Results in all Courses .....                                             | 72 |

# 1. INTRODUCTION

## 1.1 Introduction

Outcomes Based Learning (OBL) is the important transformation in education in the last decades. OBL aims at the student-centered approach which focuses on clear expectations of what a student will be able to do at the end of the learning process [1]. Student-centered approach also provides flexibility in teaching methods [2], student involvement in the teaching process [3], and also, it opens the door toward personalizing the learning process [4].

Generally, personalization is the evolution of meeting the user characteristics and styles to get a better experience. Currently, digital service providers are seeking to improve the user's experience by allowing them to customize their profiles so that the services act as their needs. Personalization in learning is the way of providing a learner with learning resources that comply with his learning needs. Learning personalization occurs by tracking and modeling the learner interaction within the learning environments. Also, the Learning Profile (LP) is the learner model that responsible to personalize learning for a learner based on the learning needs. Thus, it holds all information about a learner performance, academic achievements and learning styles.

In this research, we designed and implemented a model for learning personalization in an online learning environment. The model aims at personalizing learning to comply with the learner needs by constructing a dynamic learning profile (DLP) for capturing the LO achievements of the learner.

Basically, the learner model in DLP is represented by the LOs achievements of the learner. Once a learner has enrolled in a course, the course LOs became intended LOs for a learner. In this case, DLP is responsible or tracking the learner LOs achievements

during his study to identify his learning needs. In this research, the learner model in DLP is composed of three components: LOs Achievements Tracking (LO-AT), LOs Achievements Evaluation (LO-AE) and LOs Achievement Profile (LO-AP). And with these components, DLP will be able to comply with the learner needs based on his LOs achievements; and it will provide the learner with a clear expectation of his progress in the course. Moreover, the learner will be able to search for particular learning objects related to a specific LO to improve his achievement. Furthermore, in employment, the learner will have a personal resume full with his achievements in terms of what he knows and able to do to match his qualification with the job needs.

In particular, the optimal use of the DLP is to be used in an online learning environment based on LOs. In this environment, LOs are linked with learning objects, and the DLP is connected with learning object recommender system. Furthermore, constructing the course will be easier in terms of all learning objects get retrieved automatically as soon as the instructor assigned the course LOs. And the learning object recommender system starts sensing the progress of the learner LOs achievements in the DLP. And then, the learning object recommender system gives the learner more relevant learning objects to improve his knowledge and achievements.

And, in purpose of keep improving the course, the DLP is able to offer instructors with detailed information on their learners' achievements, and they also will be able to identify the difficult concepts and difficult LOs to improve the course with learning resources and with effective learning strategies.

## **1.2 Problem Statement**

Currently, Online learning environments are commonly used by the educational institutions to deliver and manage courseware for students and learners. Traditionally,

learning content in the online courses is provided by the teacher or by the course designer. And for learners there are challenges in terms of they should use the given learning content to study the course regardless of their actual learning needs. Moreover, even the learning outcomes are mentioned in the course, but there are no visible link between them and the assessments or the content. Therefore, for learners it is not easy to have expectations on what they know or able to do .

In this research, we introduced a dynamic learning profile (DLP) that can be integrated with any legacy educational system. The DLP idea lies on linking the LOs directly with assessments, then evaluating LOs for each learner and finally, stor the LOs evaluation as achievements in the learner profile. In this way, the DLP will has full information on the learner performance based on his achieved LOs. And based on this learners will be able to visualize his acctual achievements and learning needs based on the LOs. Therefore, learners will have full records for what they know and able to do. Furthermore, learners will be able to improve their knowledge and skills by searching for learning content that relevant to their needs in the DLP.

### **1.3 Research Questions**

- How can we design and implement a Dynamic Learning Profile (DLP) based on the achieved LOs of a learner to identify his learning needs?
  1. How can we evaluate a learner LOs achievements?
  2. How can we track the learner achievements?
  3. How can we build a learning profile?

## 1.4 Objectives

The aim of this work is to design and implement a model to personalize learning based on learners LOs achievements in an online learning environment with the following sub-objectives:

- Design and implement a Dynamic Learning Profile (DLP) to identify the learner needs.
- Evaluate the learner achieved learning outcomes.
- Keep updating the DLP with the learner progress in his LOs achievements.

## 1.5 Methodology

This research is conducted in the following phases:

- **Study Related Work**

The study is conducted based on learning personalization and measuring LOs achievements. Results and suggestions to improve the models are presented in Chapter 2.

- **DLP Model**

In Chapter 3, the DLP model is introduced with details to describe its components and environment.

- **Modeling and Design**

In Chapter 4, abstract modeling is used including structural and behavioral modeling to describe the new model and its functionalities such as Use case diagrams, class models, activity diagrams, schemas, and algorithms.

- **Implement a Proof of Concept**

A full description of the proof of concept is provided in Chapter 5, including methodology, tools, database design, and interfaces.

- **Testing and Results**

In Chapter 6, we validated the developed model by conducting a real experiment, the results and analysis are also represented in this Chapter.

- **Conclusion**

Chapter 7 is describing the summary of the research and the impact of using this work in improving the learning process and the potentials of improving this work in the future.

## **2. RELATED WORKS**

In this Chapter, we will make a literature review on both learning personalization and LOs achievement evaluation methods. Also, in the last section, we will provide an analysis of the previous work and conclusion.

### **2.1 Learning Personalization**

Generally, personalization in online learning is the way of providing the learners with learning content based on his cognitive state (actual knowledge and skills) and learning styles or preferences [4]. Also, learner profile is represented by a cognitive state and a set of learning preferences [4]. Therefore, learning profile has the main role in personalizing learning for a learner; it holds all the reflected information that generated by the learner interaction in a given online learning environment [5]. The authors in [6] also, defined the process of learning personalization as, *“the learning process needs to take into account the user’s preferences and personal needs. This implies either that the user is in position to explicitly specify these preferences or that the system has the ability to infer them through a monitoring process”*.

#### **2.1.1 Intelligent Web Teacher for Learning Personalization**

The Intelligent Web Teacher (IWT) [7] and [8] is a learning platform for personalizing the learning process. In IWT, the authors used the semantic web approach in retrieving, organizing and customizing learning objects according to domain concepts and learners’ needs. For that purpose, the authors developed a learning profile which consists of two models: the knowledge model for modeling the domain concepts (educational domains) as ontologies; and the learner’s model which composed of two modules the cognitive state and the learner’s preferences. The cognitive state module is

represented by evaluating the acquired knowledge of the learner on each domain concept. And the preferences module is responsible for capturing information about the learner preferred types of learning resources and learning styles.

In this approach, a course is constructed dynamically by customizing the knowledge model to match the learning profile of each learner based on his cognitive state and learning preferences.

### **2.1.2 E-learning object recommender system**

The E-learning object recommender system (e-LORS) [9], is introduced to provide the learners with learning objects that will comply with their learning needs. To identify the learners' need, the authors developed a mechanism to construct learning profile for each learner. And the learning profile is constructed using 3 techniques: structured questionnaires to identify the user needs, monitoring the explicit and implicit actions of the learners over the system, and identifying the learning style for each learner based on Felder and Silverman [10] learning style categorization.

### **2.1.3 User Profile Modeling based LMS**

The authors in [6], proposed User Profile Modeling based Learning Management System (LMS), which is an online learning platform that able to adapt each user needs. The authors in [6] focused on modeling the user profile into three logical layers. The first one is the monitoring layer; which responsible for tracking the user interaction with the LMS. The second layer is the modeling and evaluation; which responsible for modeling and evaluating the collected data from the monitoring layer. And the last layer is the adaptation layer; which responsible for updating the profile preferences of a learner based on the first two layers.

Therefore, based on the three logical layers, the authors proposed four target parameters in the user profile preferences to be constantly tracked, evaluated and updated. The first one is the Content Difficulty in relation to the level of the learner's knowledge. The second one is the Content Volume which refers to the amount of information the learner wishes to study. The third one is Interactivity, at which the learners feel that the environment is enough smart to meet their needs. And the last one is the Interface, which refers to the content types. Furthermore, the authors used the prediction technique in identifying the learner needs. Thus, they used Bayesian Networks to analyze the four target parameters after collecting data on each parameter dependencies. Then by keeping these parameters updated, the system will be able to provide the user with learning resources based on his needs.

#### **2.1.4 Personal Achieved Learning Outcomes**

Personal Achieved Learning Outcomes (PALO) [11], provides a schema to facilitate storing, retrieving and managing the personal achievements in any learning context based on learning outcomes. In PALO, the authors described the learning achievements as knowledge, skills or competence and attained by assessments or other evidences. Also, the authors in [11], defined the learning needs as the skills, knowledge, and competencies that need to be achieved by a learner in order to perform a particular task. The authors in [11], developed PALO based on the iCOPER Learning Outcomes Definition (LOD) [12], which is developed also based on the IEEE RCD [13] learning outcomes description standard.

iCOPER (LOD) [12] refers to *“a conceptual base schema for describing and sharing learning outcome definitions in the context of online and technology enhanced learning”*. Consequently, iCOPER (LOD) [12] defined the learning outcomes (LOs) as

what a learner knows, understands (knowledge), and is able to do (skills and competencies) after completing a learning process.

## **2.2 Measuring Learning Outcome Achievements for Learners**

In the last ten years, the European educational institutes had started to shift from the traditional approach in education to the active learning, which aims at the outcomes based learning (OBL) approach. Thus, in 2008, the European Centre for the Development of Vocational Training (Cedefop) introduced a conceptual and political framework [14] towards adopting OBL approach in educational and training institutes.

Generally, a course or a learning module in the OBL approach consists of three main components: Learning Outcomes (LOs), learning content and assessment tasks. These components should be aligned together so that students will have content for learning, clear expectation for what they will achieve from this content and assessing tools to measure their LOs achievements at the end of the learning process.

For assessments, Ramsden in [15], stated that the assessment is the curriculum because the students learn what they think will be included in the assessments. Moreover, Kennedy in [16], refers to the LOs that, they should be written in a way that they are capable of being assessed.

### **2.2.1 ALOA Conceptual Model**

Aligning Learning Outcomes with Assessment (ALOA) [17] is a conceptual model defended by different authors in [18], [19] and [20]. It focuses on LOs and assessment methods. For LOs, ALOA stated that teaching, learning activities and assessments should be derived and defined by the course LOs. And assessment tasks should measure the LOs of the course. And in this research we will focus in finding a method to measure the learning outcomes based on the formal assessments.

### 2.2.2 Assessing the Attainment Of course Outcomes

As described above in [16] and [17], assessments should be aligned with LOs, and LOs should be measured by assessments. In this research, we are focusing on finding an automated model to measure and evaluate LOs achievements for a learner during his learning process.

For LOs evaluation, the authors in [21], developed the CO-Attainment Method to evaluate the learning outcomes (they called it Course Outcomes (COs)) using the existing students' marks in the course assessments. For that purpose, the authors in [21], applied the CO-attainment method using the Assessment-CO Matrix that shown in Table 1. In this matrix, the authors defined the assessments types as rows, and the learning outcomes or the course outcomes (COs) as columns. Consequently, for each assessment type the authors distributed percentages for all COs as weights or scores with total 100%.

| Assessment Type | Course Outcomes (CO) |     |     |     |     |     |     |     |     |      |
|-----------------|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|
|                 | CO1                  | CO2 | CO3 | CO4 | CO5 | CO6 | CO7 | CO8 | CO9 | CO10 |
| Final Exam      |                      | 20% | 40% | 40% |     |     |     |     |     |      |
| Test            | 30%                  | 30% | 40% |     |     |     |     |     |     |      |
| Quizzes         | 30%                  | 30% | 20% | 20% |     |     |     |     |     |      |
| Assignments     | 10%                  | 20% | 50% | 20% |     |     |     |     |     |      |
| Project         |                      |     |     | 20% | 20% | 20% | 20% |     |     | 20%  |
| Special         |                      |     |     |     |     |     |     |     |     |      |

**Table 1: Assessment-CO Matrix**

| Assessment         | Final exam | Test | Quizzes | Assignment | Project | Special | TOTAL |
|--------------------|------------|------|---------|------------|---------|---------|-------|
| Overall percentage | 50%        | 15%  | 5%      | 10%        | 20%     | -       | 100%  |

**Table 2: Assessment Distribution**

And to find the attainment of each student in a specific CO, the authors multiplied the percentage of each CO in each assessment type with the overall weight of the assessment

in the course that shown in Table 2. Then they find the summation of the multiplication results for each CO along all assessments, as shown in the following equations:

$$\text{MarksCO1} = (0\% \text{ CO1} * 0.50 \text{ percentage of Final exam}) + (30\% \text{ CO1} * 0.15 \text{ percentage of Tests}) + (30\% \text{ CO1} * 0.05 \text{ percentage of Quizzes}) + (10\% \text{ CO1} * 0.10 \text{ percentage of Assignments}) + (0\% \text{ CO1} * 0.20 \text{ percentage of Project}) + (0\% \text{ CO1} * 0.0 \text{ percentage of Special})$$

After skipping the zeros values:

$$\text{MarksCO1} = (0.3\text{Task} \times 0.15) + (0.3\text{Quizzes} \times 0.05) + (0.1\text{Assessments} \times 0.1).$$

## 2.3 Conclusion

The previous studies in [7] and [8], introduced learning personalization in an online learning environment from two aspects: learner cognitive state based on educational domains and learner preferences based on the learning styles. Moreover, the authors in [7] and [8], constructed the learning profile based on the cognitive state of a learner by assessing him on particular educational domains in the course. On contrary, our research focuses on constructing the learning profile based on assessing the learning outcomes (LOs) for learners.

The authors in [9], introduced a recommender system to provide a learner with learning objects based on his needs. In [9], the authors identified the learner's needs using questionnaires and monitoring the learner interactions with the learning system. But in this research, we are focusing on identifying the learner's needs based on his learning outcomes achievements.

And in [6], the authors focused on modeling the user profile. Thus, they divided it into three logical layers: monitoring layer, modeling and evaluation layer, and adaptation layer. The authors also targeted three parameters for constructing and updating the user

profile such as content difficulty, content volume, interactivity and interface. And in our research, the target parameter is the learning outcome achievements.

Also, the authors in [6], used the Bayesian Networks to predict the learner's needs based on previously collected data about the learner performance, grades, and styles. And in our research, we identify the learner's needs by capturing the progress of his LOs achievements.

The authors in [11], introduced PALO as a schema to facilitate storing, retrieving and managing the personal learning achievements based on the learning outcomes; without describing a technique to evaluate these achievements. The authors in PALO defined the learning outcomes using the iCOPER (LOD) definition [12], as what a learner knows, understands (knowledge), and is able to do (skills and competencies) after completing a learning process. Furthermore, the authors in [11], described the learning needs as the learning outcomes that need to be achieved by a learner.

Consequently, in our research we are focusing on identifying the learner's needs and constructing a learning profile based on the learning outcomes achievements as mentioned in PALO. And we need also an evaluation technique to evaluate the LOs achievements as mentioned below.

The authors in [21], introduced the CO-Attainment Method to measure the LOs achievements in the formal assessments for engineering courses. The method aims at constructing the Assessment-CO Matrix which contains all assessment types as rows and linked with the course LOs as columns with percentages distribution for all LOs. And to find the attainment of each student, the authors in [21], multiplied the percentage of each LO in each assessment type with the overall weight of the assessment in the course.

However, in this research we developed a general formula to evaluate the LOs in the formal assessment for any courses by introducing the Learning Outcomes Achievement Evaluation Matrix (LO-AE Matrix).

### 3. DLP MODEL

In this Chapter, we will describe the implemented DLP model in this research. The new model aims at constructing a DLP with three layers as described in the below subsections.

#### 3.1 DLP Overview

A Dynamic Learning Profile (DLP) is a learning personalization model in an online learning environment. It aims at constructing a DLP to comply with the learner's needs by tracking and evaluating his LOs achievements.

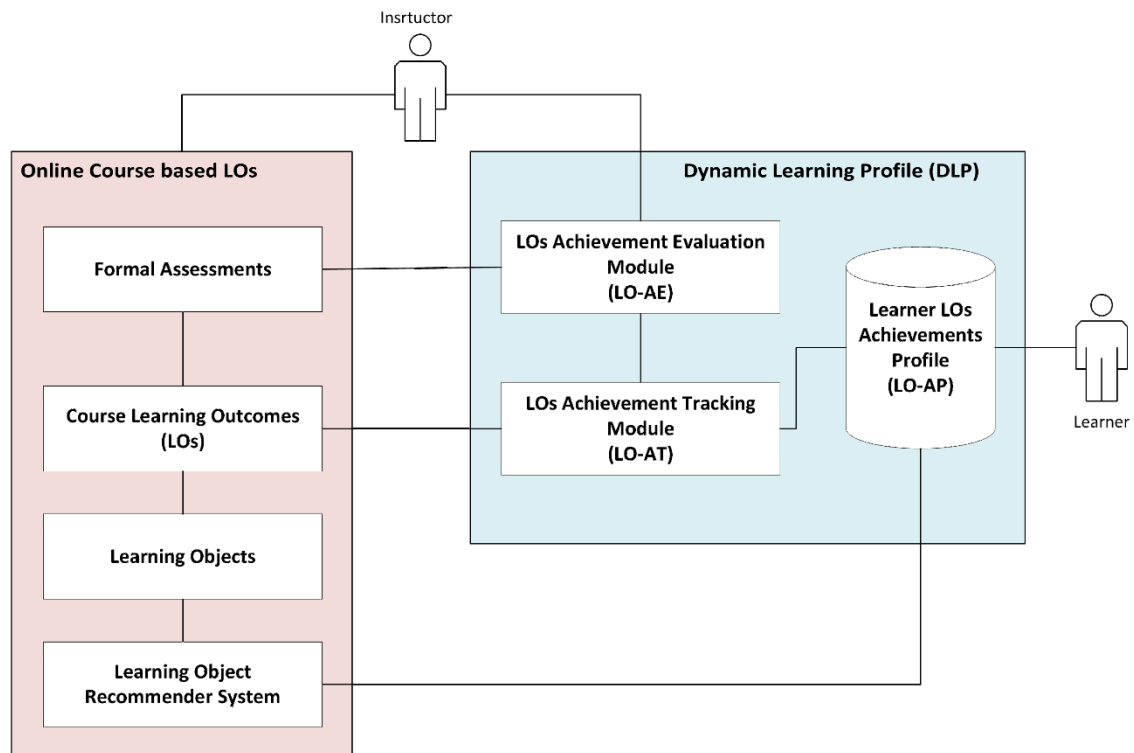
The learner model or the target parameter in the DLP is represented by the LOs achievements of a learner. Therefore, DLP is composed of three modules: LOs Achievement Tracking module (LO-AT), LOs Achievement Evaluation Model (LO-AE) and LOs Achievement Profile (LO-AP) as shown in Figure 1.

In DLP, the LO-AE is responsible for evaluating the LOs achievements for learners by linking LOs with assessments. For that purpose, instructors should link each question in the assessment with a specific learning outcome using the LO-AE Matrix, and in section 3.3.2 we will introduce the evaluation method in details.

The other module in DLP is the LO-AT, which is a logical module and it represents the interaction between LOs, LO-AE and LO-AP. In Figure 1, LO-AT is linked with the LOs and LO-AE and LO-AP. Initially, LO-AT is responsible for capturing the LOs and store them in the learners LO-AP. And during the semester, LO-AT is responsible for updating LO-AP with any changes that may occur in the LO achievements of the learners by tracking and capturing the LO-AE results at each change.

Furthermore, the optimal use of the DLP is when it is connected with learning environment that contains learning objects recommender system. In this case, the learning

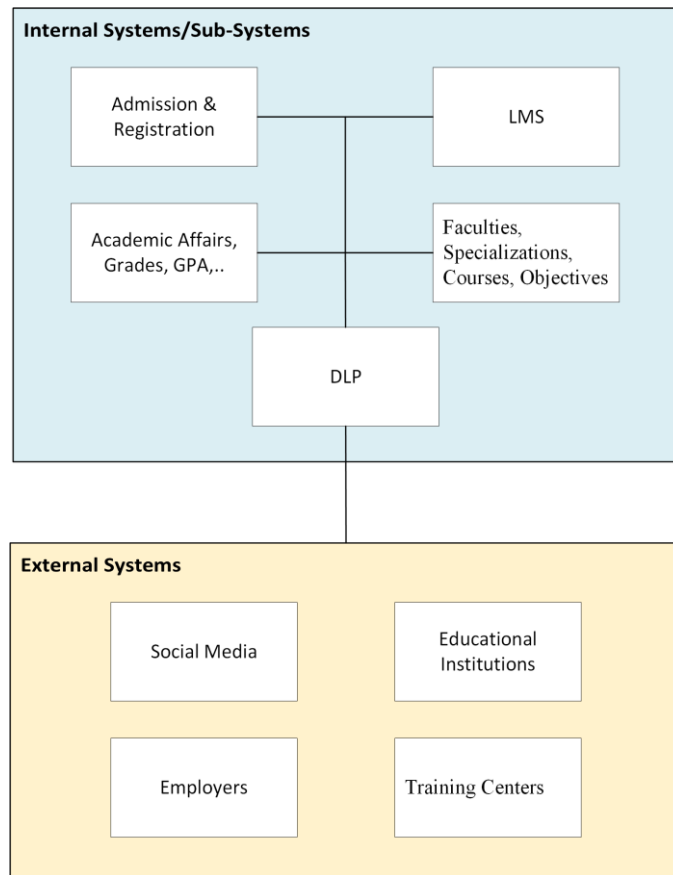
objects recommender system will be able to provide the learner with learning objects that suitable to his needs based on the DLP.



**Figure 1: DLP Architecture**

### 3.2 DLP Environment

As shown in Figure 2, DLP model can be considered as a reusable system component that can be integrated with any existing educational legacy system. It gives the legacy systems the opportunity to operate as a learning management systems based on DLP. Moreover, it helps the learners to personalize their learning process as their needs. In addition to that, DLP provides the legacy learning system the opportunity to interact with other external environments. So that learners can share their learning profiles with others on social networks or business-oriented social networks to match their qualifications with employers or with other educational institutions to insist their admission in higher studies.



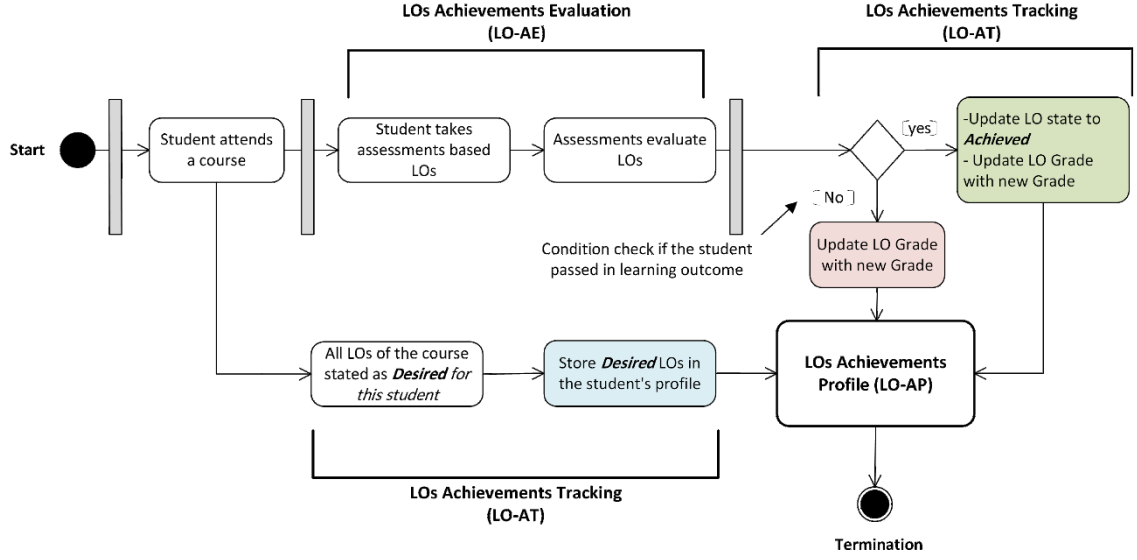
**Figure 2: DLP Environment**

### 3.3 DLP Components

As discussed above in section 3.1, DLP consists of three modules: LO-AP, LO-AE, and LO-AT as a logical module. The Activity Model in Figure 3, shows the relationship and the interactions between the three modules inside the DLP as explained below.

Initially, once a learner is attended a course the LO-AT is capturing all the LOs of the course and store them in the LO-AP as *Desired* LOs. And during the semester, the LO-AE is responsible on evaluating the LO achievements of the learner. In this phase, the LO-AT also is responsible for tracking and capturing the evaluation results from LO-AE and update the LO-AP of the learner with all changes in the LOs achievements. And as soon as the LO cumulative score reaches the success score of the LO, LO-AT updates the

LO state from *Desired* to *Achieved*, otherwise LO-AT updates the LO state to *Unachieved* at the end of the semester.



**Figure 3: Activity Model for DLP**

### 3.3.1 LOs Achievements Profile (LO-AP)

LO-AP aims at storing, updating and sharing the learner personal information that describes his achievements during his learning life. Consequently, by modeling this personal information, LO-AP will be able to identify the learning needs of the learner.

Generally, LO-AP consists of two parameters: Achievement description, to describe the educational context of the achievements as learning outcomes, and Achievement Progress to describe the LO achievements progress, state, and scores. In this research, we adopted PALO model [11] for implementing the LO-AP. Thus, it provides a schema to store, retrieve and describe the personal LOs achievements for a learner which attained by assessments or other evidence.

Furthermore, PALO is composed of 6 data elements as shown in figure 4, and can be represented in LO-AP as *Personal Achievement Profile* element, which holds all

information about a learner such as a learner name and description. *Learning Outcomes* elements which are a textual element to describe the LO achievements of a learner. *Assessments Records* element which is evidence and progress records to describe score, level, date, assessing body and other information for each LO achievement. *Achievements* element holds a learner LO achievements that described in *Learning Outcomes* elements and has evidence and progress in *Assessments Records* element. *The level* element which provides a weighted and textual ranking for each LO achievement. And the last element is the Context which describes the big umbrella that the LO achievement is belonging to, such as textual information for the educational domain or the course name.

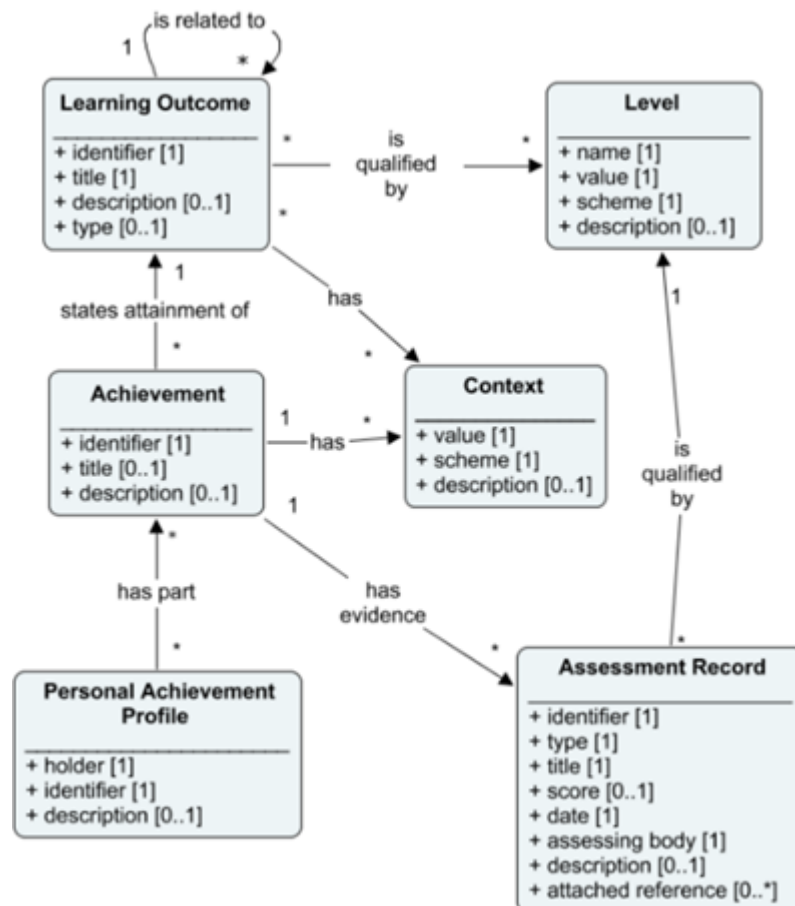


Figure 4: PALO Schema

### 3.3.2 Learning outcome Achievements Evaluation Model (LO-AE)

As we mentioned before in Chapter 2, the authors in [18], [19] and [20] stated that in ALOA, teaching and assessments should be aligned with LOs. And the authors in [17] stated that assessment should measure the LOs of the course. In this section, we will discuss an improved version of the Assessment-CO Matrix [21] which aims at aligning LOs with assessments and giving each LO a specific grade weight by implementing the LO-AE Matrix.

LOs Achievement evaluation model (LO-AE) aims at evaluating LOs achievements by aligning each LO directly with a question in the formal assessments. Therefore, we need to design each assessment as questions provided with grade weights and linked with a LOs. In this way, the LO-AE Matrix can be implemented as shown below in Table 3. The columns are representing LOs and rows are representing questions and the cross point between each column and row is representing the grade. And to calculate the student achievements in a particular LO in an assessment, we simply find the summation of the grades in the LO column. Consequently, for the wider level, we find the summation for that LO column through all assessments in the course to have the final grade of the LO achievements as shown below in Table 4.

Furthermore, the LO-AE Matrix should satisfy the following rules: firstly, each assessment should be linked with a set of LOs, secondly, each question should have a grade, thirdly, zero or many questions can be linked to the same LO. And fourthly, the total grades for all LOs/questions is equal to the total percentage of the assessment.

| <i>Assessment A1</i>       | <i>LO1</i> | <i>LO2</i> | <i>LO3</i> | <i>Total Assessment Percentage</i> |
|----------------------------|------------|------------|------------|------------------------------------|
| <i>Q1</i>                  | 8          |            |            | 25%                                |
| <i>Q2</i>                  |            | 5          |            |                                    |
| <i>Q3</i>                  | 2          |            |            |                                    |
| <i>Q4</i>                  |            |            | 5          |                                    |
| <i>Q5</i>                  |            | 5          |            |                                    |
| <i>Total LO Percentage</i> | <i>10%</i> | <i>10%</i> | <i>5%</i>  |                                    |

**Table 3: LO-AE Matrix for Assessment A1**

| <i>Assessments</i>         | <i>Q</i>  | <i>LO1</i> | <i>LO2</i> | <i>LO3</i> | <i>LO4</i> | <i>LO5</i> | <i>Total Assessment Percentage</i> |
|----------------------------|-----------|------------|------------|------------|------------|------------|------------------------------------|
| <b>A1</b>                  | <i>Q1</i> | 8          |            |            |            |            | <b>25%</b>                         |
|                            | <i>Q2</i> |            | 5          |            |            |            |                                    |
|                            | <i>Q3</i> | 2          |            |            |            |            |                                    |
|                            | <i>Q4</i> |            |            | 5          |            |            |                                    |
|                            | <i>Q5</i> |            | 5          |            |            |            |                                    |
| <b>A2</b>                  | <i>Q1</i> |            | 5          |            |            |            | <b>25%</b>                         |
|                            | <i>Q2</i> |            |            | 5          |            |            |                                    |
|                            | <i>Q3</i> |            |            | 5          |            |            |                                    |
|                            | <i>Q4</i> |            |            |            | 10         |            |                                    |
| <b>A3</b>                  | <i>Q1</i> | 5          |            |            |            |            | <b>50%</b>                         |
|                            | <i>Q2</i> |            | 5          |            |            |            |                                    |
|                            | <i>Q3</i> |            |            | 10         |            |            |                                    |
|                            | <i>Q4</i> |            |            |            | 10         |            |                                    |
|                            | <i>Q5</i> |            |            |            |            | 20         |                                    |
| <i>Total LO Percentage</i> |           | <i>15%</i> | <i>20%</i> | <i>25%</i> | <i>20%</i> | <i>20%</i> | <i>100%</i>                        |

**Table 4: LO-AE Matrix for all Assessments in the Course**

### LO-AE Algorithms

As a general case, we implemented LO-AE algorithms to measure the LOs achievements for learners in any course using LO-AE matrix.

Let *Assessment*  $A_k$  is a 2D matrix and has *Questions* from  $1 \rightarrow m$ ;  $Q_1, Q_2, \dots, Q_m$  and *Learning Outcomes*  $O$  from  $1 \rightarrow n$ ;  $O_1, O_2, \dots, O_n$ .

Then

The *Weight*  $W_k$  for each learning outcomes  $O_j$  in  $A_k$  can be measured as a summation of

$$A_k[1,j] + A_k[2,j] \dots + A_k[m,j]$$

$$W_k(O_j) = \sum_{i=1}^m A_k[i,j]$$

And

The *Weight* for all  $O_n$  in  $A_k$

$$O_n = \sum_{j=1}^n O_j$$

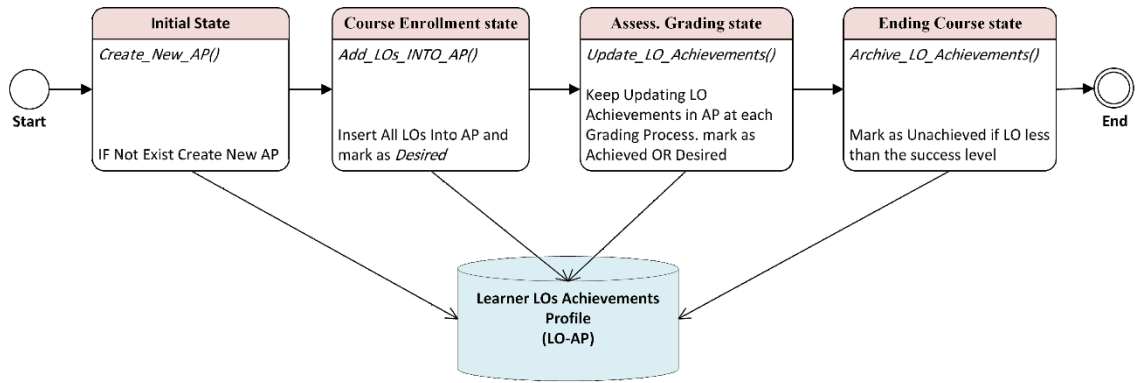
And

For Assessment  $A_1, A_2, A_3 \dots A_x$  the *Weight*  $W$  for  $O_j$  in all  $A_x$

$$W(O_j) = \sum_{k=1}^x W_k(O_j)$$

### 3.4.3 LO Achievements Tracking Module (LO-AT)

LO-AT is a logical component and used to control the flow in DLP. LO-AT keeps the LO-AP up to date with LOs achievements through four states of the course: Initial state, Course Enrollment state, Assessment Grading state and Ending Course state as shown below in Figure 5.



**Figure 5: LO-AT Course States**

The four states of the course represent the dynamic changes in the learner LO-AP which controlled by the LO-AT module. Initially, when a learner joins the system for the first time, LO-AT is responsible for preparing the way of using LO-AP by configuring a new empty LO-AP for a learner using `Create_New_AP()` algorithm. The second state is the Course Enrollment State. And once a learner joins a new course, each LO in the course is appended to his LO-AP as Desired using `Add_LOs_INTQ_AP()` algorithm. and if LOs already exists in his profile from another course, LO-AT updates their state to Desired. Consequently, Assessment Grading State is the longest state in the course lifetime. In this state, LO-AT is responsible for keeping LO-AP updated with LOs achievements that evaluated from the assessment grading processes in the LO-AE. And if the LO achieved score become greater than or equal the LO reference weight (success level), the LO-AT updates the LO state to Achieved. The last state in the Course is the Course Ending State. In this state, LO-AT is responsible for archiving all LOs in LO-AP to their final state by changing them to Unachieved if the LO achieved score is less than the LO reference weight (success level).

## **4. MODELING AND DESIGN**

### **4.1 Methodology**

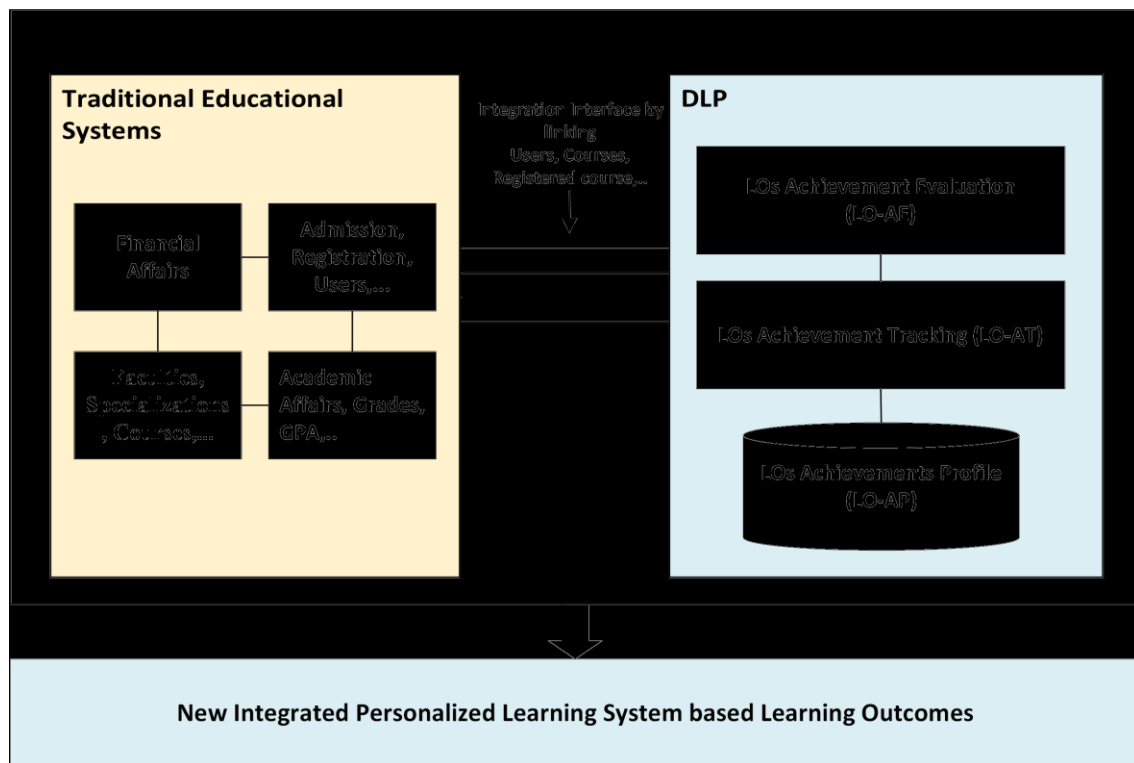
DLP is designed and implemented based on the Reuse-Oriented approach [22]. This approach is used in software engineering when adding new components or modifying existing components of existing legacy systems.

In this chapter, UML modeling techniques are used to identify and describe DLP model from different views such as:

- DLP Environment Architecture.
- Internal interactions for the model components.
- Algorithms for implementing the model.
- Structural analysis of the model components.
- Architecture layering for the model functionalities.

### **4.2 DLP Environment**

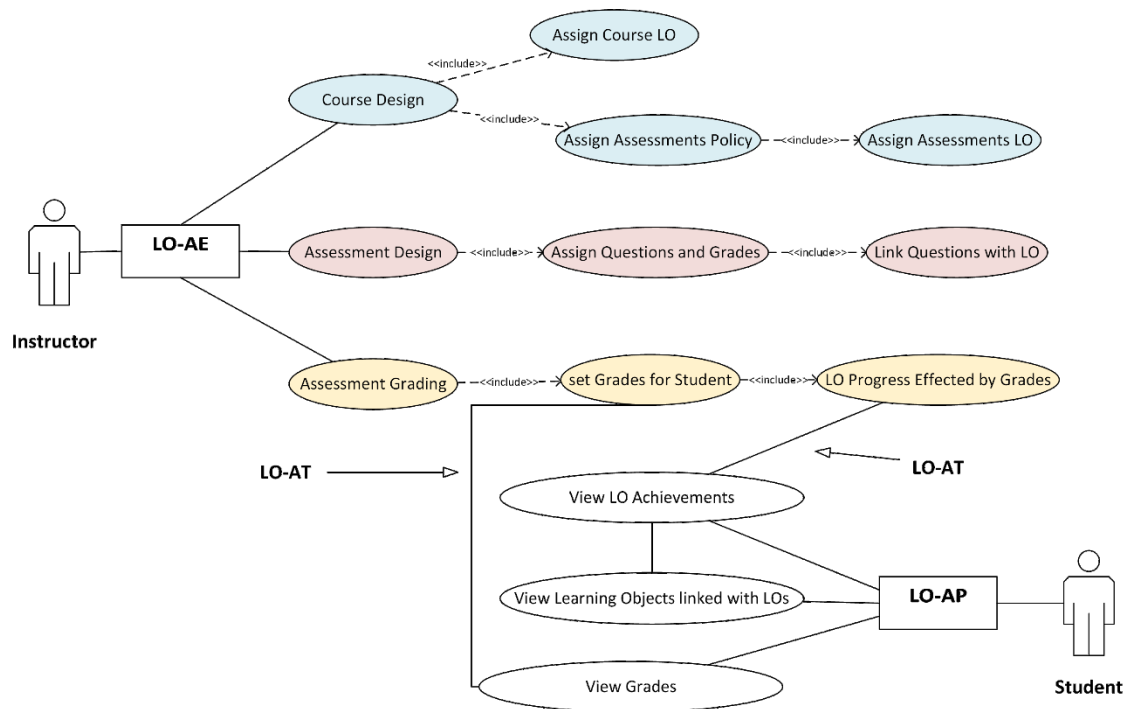
As stated in Chapter3, DLP model is a new system component that can be integrated with any educational system. Therefore, in this research the integration interfaces are implemented based on linking DLP with key data tables that should exist in any legacy educational database such as Users, Courses, Student Registered Courses and others, as shown below in Figure 6.



**Figure 6: New Integrated System**

### 4.3 DLP Use Case

In order to understand the model components, and identify the user interactions, a use case model is developed as shown in Figure 7. This model represents all interactions in the DLP model. The main two actors are instructors and students with a sequence of interactions through the DLP components.



**Figure 7: Use Case Model for DLP**

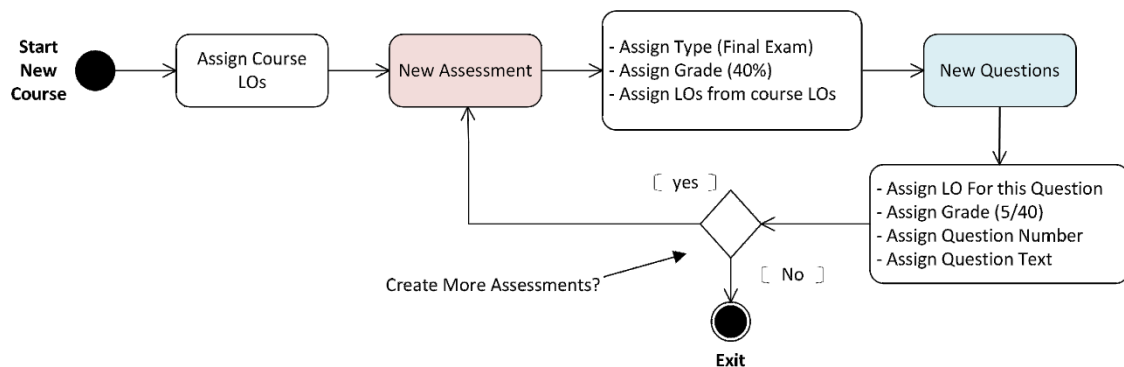
### **Instructor Roles:**

As Shown in the Use Case Model, the LO-AE is responsible for evaluating LOs for learners through a set of interactions that controlled by the instructors as follows:

- 1- **Course design**, once the course is created, some settings should be assigned as the following:
  - Assign LOs for the course, he can select them from the predefined repository for LOs.
  - Create the assessments policy for this course, such as adding a Midterm exam with weight 30%, a Final exam with weight 40% and a Project with weight 30%.
  - Assign LOs for each Assessment, such as selecting 3 LOs from the course LOs.
- 2- **Assessment Design**, after creating assessments, the instructor has to continue setting up the assessment as the following:

- For each assessment, create questions with grade distribution, such as for Midterm, Q1→ 10 points, Q2→10 points and Q3→10 points.
  - For each question within the assessment, assign LO to be measured by this question, i.e. the LO has the same grade weight as the question.
- 3- **Assessment Grading** has two interaction, the first is caused by the instructor and the last is a post-result of the first one.
- After students took the assessment, the instructor will use the grading sheet to put scores for students.
  - For each student, the LOs progress is effected directly from the instructor grading.

For further clarification inside the instructor interaction, an activity model is developed to describe the instructor's activities in this process starting from creating a new course until designing all assessments in a sequential way, shown in Figure 8.



**Figure 8: Activity Model for Setting-Up Course and Assessments in LO-AE**

### Student:

Using LO-AP, students will be able to interact with the system by viewing his grades, viewing his LO achievements and view Learning Objects that linked with his LOs.

Moreover, the dependencies between the instructor functionalities and learner functionalities represent the LO-AT components in DLP.

Generally, in this use case model, the student is affected by two kinds of interactions the first one by the instructor interactions such as creating assessments and grading. The second one is the dependencies which represent the LO-AT, such as when the system is updating the students LO Achievements based on the instructor grading.

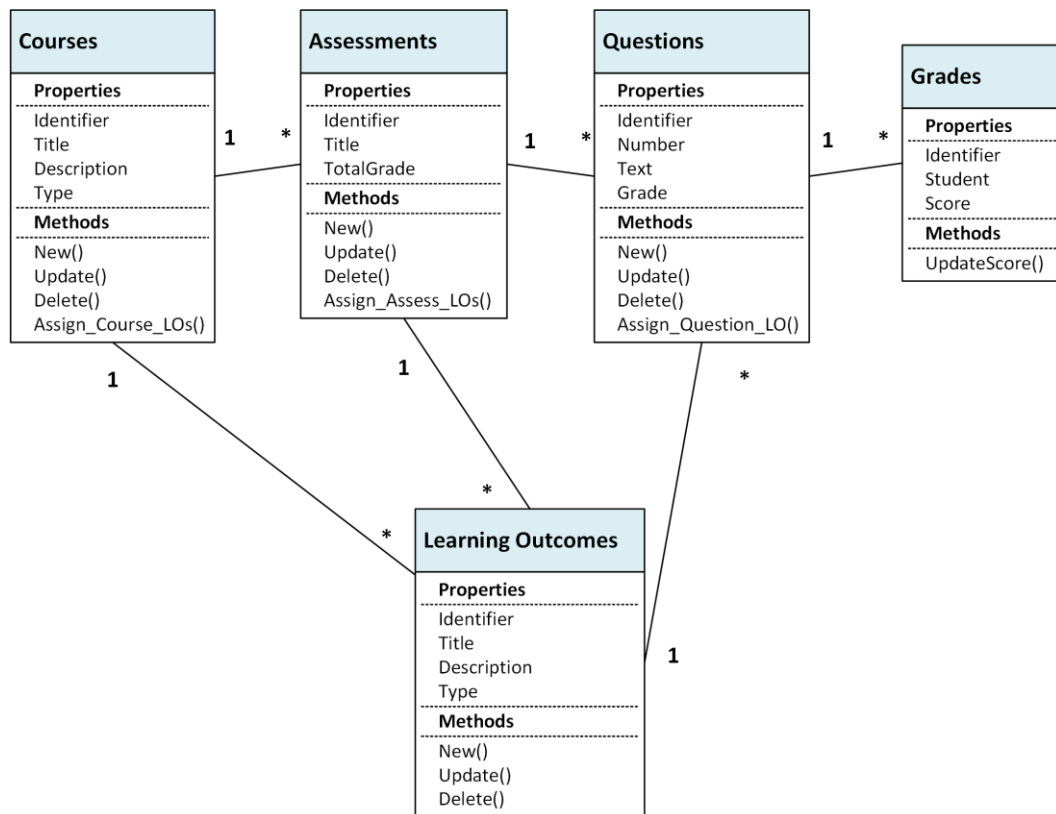
The next sections in this Chapter will show how the DLP components are designed in this research, and how the interactions occurred between them.

## **4.4 LO-AE Design and Algorithms**

As described in chapter 3, the LO-AE is a model to evaluate the learner LOs achievements by aligning LOs with assessing questions. Furthermore, the use case above shows that in LO-AE, instructors interact with three functionalities: course design, assessment design and assessment grading. In the below section, we will show the schema for these functionalities in LO-AE.

### **4.4.1 LO-AE Schema Design**

LO-AE schema aims at aligning LOs with assessments. Thus, it aligns courses and assessments with LOs, and store them in a way that can be evaluated for each learner. therefore, we designed the LO-AE schema as shown in Figure 9, and it contains five data elements to define the following relationships and interactions.



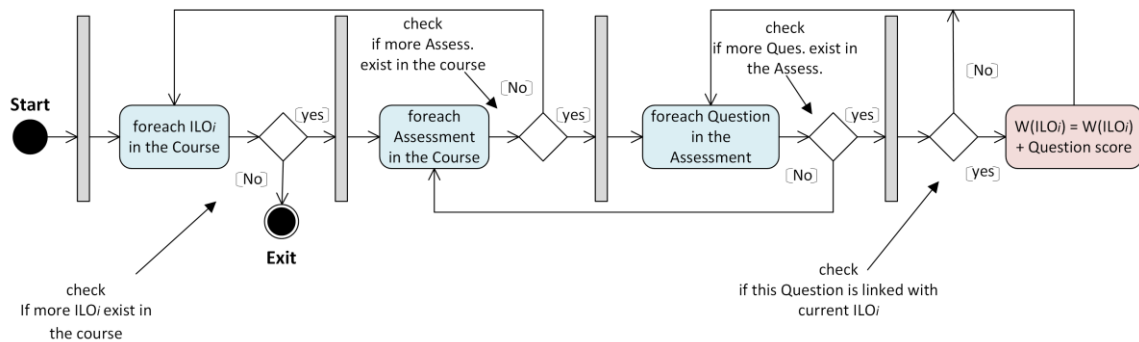
**Figure 9: Class Model for LO-AE**

- Each *Course* has one or more aligned LOs.
- Each *Course* has one or more *assessments*, as described in section 4.3 in the use case model, and one of the main roles of the instructor is designing assessments for the course and setting up its configurations such as assigning LOs, assigning questions and others.
- Each *Assessment* has one or more *LOs*, thus the instructor should assign LOs for assessment from the course LOs.
- Each *Assessment* has one or more questions with a weight grade for each question.
- Each *LO* has one or more *Questions*, and each *Question* is evaluating only one *LO*, thus the LO inherited the question's grade.
- Each *Question* has one or more *Student Grades*, this means that during the grading process for an assessment, the instructor will walk through all questions, and for

each question, he should write all students' scores in that assessment. Therefore, each record in the *questions class* will be linked to several records in the *Student Grades* class which represent all students who attended the assessment.

#### 4.4.2 LO-AE Algorithms

The LO-AE algorithm aims at evaluating LOs achievements at each grading process in assessments. In Chapter 3, we described LO-AE Algorithm in math notations to evaluate LOs in LO-AE Matrix. Thus, to simplify the algorithm, we developed an activity model as shown in Figure 10. The activity model contains 3 nested for loops to evaluate each LO along all assessments in the course and along all questions for each assessment.



**Figure 10: Activity Model for LO-AE Algorithm**

In this research, the LO-AE is evaluating the LOs by running Algorithm1 and Algorithm2. The first one, to get the total LO grade weight in the course. And the second, to get the LO achieved grade for a learner at each assessment grading process. And below we described each algorithm as follows:

##### **LO-AE Algorithm1: Get Total LO Grade Weight Algorithm**

As a case from the general algorithm, the below algorithm in Figure 11 returns the total weight grade of the LO within all assessments of the course. The Total weight of LO will be used as the reference LO grade to what a learner will be achieved.

```

LO-AE Algorithm1: Get Total LO Grade Weight
-----
1  // Calculate the LO total weight grade along all assessments in the course
2  Get_LO_Total_Grade_Weight(LO)
3  {
4      LO_Total_Weight = 0;
5      Foreach Assessment in the Course DO:
6          {
7              Foreach Question in the Assessment DO:
8                  {
9                      LO_Total_Weight = LO_Total_Weight + Question.LO.Grade;
10                 }
11             }
12     Return LO_Total_Weight;
13 }

```

**Figure 11: Get Total LO Grade Weight Algorithm**

#### **LO-AE Algorithm2: Get Learner LO Achieved Grade by Assessment**

To evaluate LO achievements, the below algorithm in Figure 12 is used to evaluate the LO achievements for a learner at each grading process.

```

LO-AE Algorithm2: Get Learner LO Achieved Grade by Assessment
-----
1  // Calculate the Achieved LO grade for a learner in an assessment
2  Get_LO_Achieved_Grade(Learner, Assessment, LO)
3  {
4      AchievedGrade = 0;
5      Foreach Question in the Assessment DO:
6          {
7              AchievedGrade = AchievedGrade + Learner.Question.LO.Grade;
8          }
9      Return AchievedGrade;
10 }

```

**Figure 12: Get Learner LO Achieved Grade by Assessment**

#### **LO-AE Algorithms Output:**

The above two algorithms can be summarized in the below formula to find the learner total LO achievements:

$$\text{Learner Total LO Achievements} = \sum \text{LO Achieved Grades in all Assessments} / \text{Total LO Grade Weight}$$

## 4.5 LO-AP Design

In Chapter 3, we described the LO-AP as a repository for the learner achievements. In this research, we developed the LO-AP class diagrams based on PALO schema [11] with some modifications in the relationships. The below class diagram that shown in Figure 13 consists of six data elements to store and share LO achievements. And we can define the following relationships and interactions.

- *Personal Achieved Profile* represents learners' information such as name and description.
- Each *Personal Achieved Profile* record has one or more *Achievements* records to describe the nature of the Achievements.
- Each *Achievements* record has one *Assessments Record* as an evidence to what a learner has achieved.
- *Assessments Record* used as an evidence to the achievement and describe the level of achievement, grade, date, assessing body and linked with the assessment records in LO-AE schema.
- Each *Levels* record describes one or more achievements in *Achievements* element, and it represents the success scale, such as grades from 90 to 100 represent level5, 80-89 represent level 4 and so on.
- Each *Context* record describes one or more achievements in *Achievements* element such as knowledge area, knowledge domain, and course description and so on.
- Each *Learning Outcomes* record describes one or more achievements in *Achievements* element.

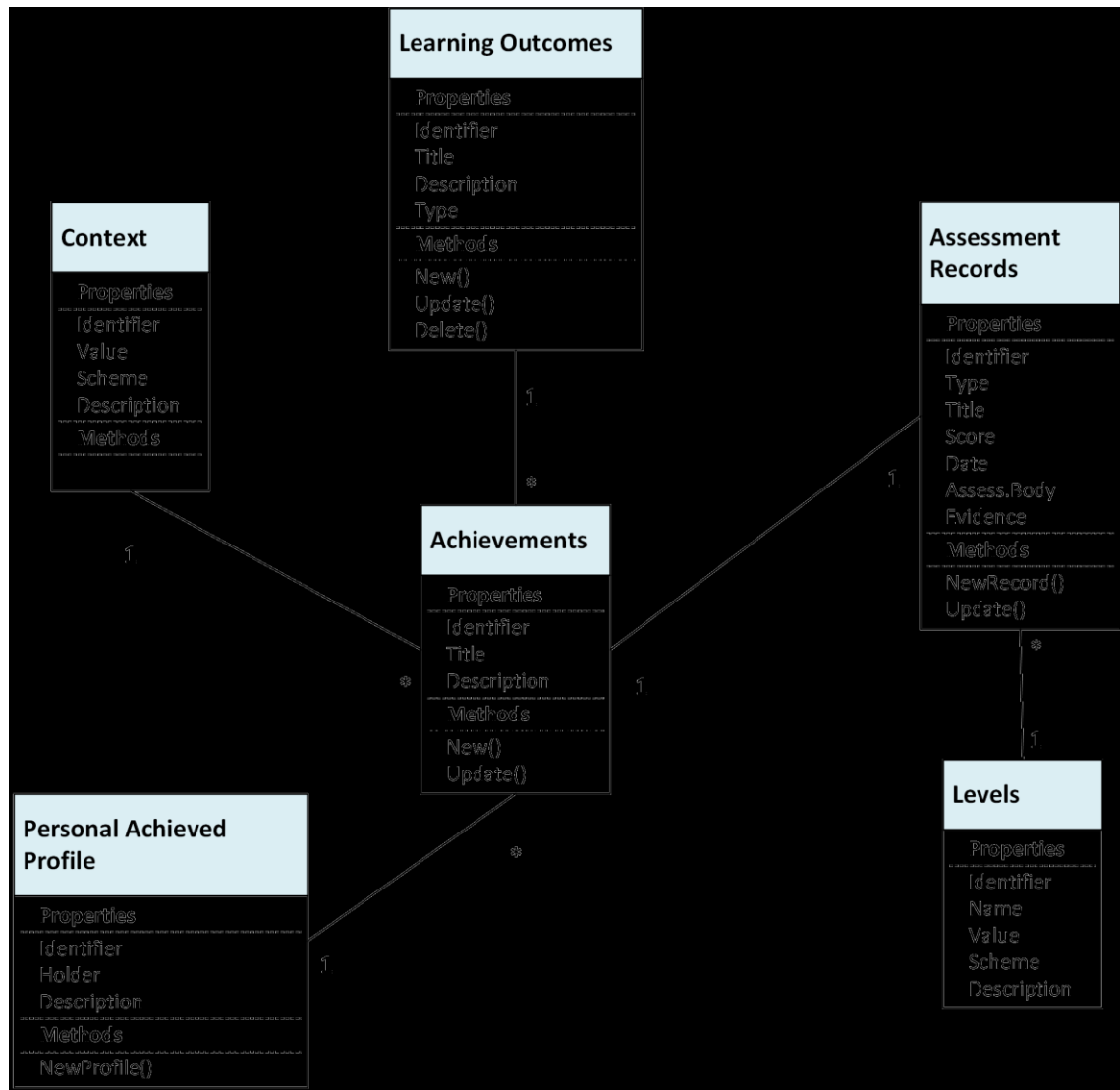


Figure 13: LO-AP Class Diagram

## 4.6 LO-AT Algorithms

As previously discussed in section 3.4.3, LO-AT controls the four states of the course. In this section, we will discuss the dynamic changes in LO-AP through the four states. And we will discuss each algorithm of each state.

### 4.6.1 Initial State Algorithm (1)

Initial State Algorithm is responsible for creating a new empty LO-AP for a learner when he joins the system for the first time. As in Figure 14 below, LO-AT is calling the method `Create_New_AP()` to instantiate a new object of the AP and define the holder and description in the *Personal Achieved Profile* element in LO-AP.

```
LO-AT Algorithm 1: Create New AP
-----
1  // Create New AP for a New Learner
2  Create_New_AP()
3  {
4      Foreach new learner on the system DO:
5          {
6              New AP Object Profile;
7              Profile.Holder = Learner;
8              Profile.Description = "some info";
9          }
10 }
```

**Figure 14: LO-AT Algorithm (1)**

### 4.6.2 Course Enrollment State Algorithm (2)

Once a learner is joint a new course, this algorithm is responsible for iterating along all LOs of the course, and for each LO it checks if the LO does not already exist from another course it calls the method `Insert_LO_in_AP()`. Otherwise, it calls `Update_LO_in_AP()`.

Consequently, the Insert method is responsible for inserting the LO into Achievements elements of the AP with Desired status, resetting the learner achieved grade to 0 and get the LO reference grade by calling Algorithm1 in LO-AE. However, calling the method Update, indicated that the LO already exists in the AP and we need to update its status to Desired. Moreover, in Update method, the LO reference grade is calculated cumulatively, by appending the new LO reference grade to the previous reference grade. In this way, the learner will have no duplicated LOs in his AP.

```

LO-AT Algorithm 2: Add All LOs to a Learner AP
-----
1  // On Course Enrollment Add all LOs to a Learner AP
2  Add_LOs_at_Enrollment()
3  {
4      Foreach learner DO:
5          {
6              // Add all LOs of the course to a learner AP
7              Foreach LO in the Course DO:
8                  {
9                      IF(LO Does Not Already Exist in Learner AP)
10                     {
11                         Add_LO_in_AP(LO);
12                     }
13                     ELSE
14                     {
15                         /* This Code Run if LO is Already taken previously
16                          in another course, then its weight calculated
17                          cumulatively.*/
18                         Update_LO_in_AP(LO);
19                     }
20                 }
21             }
22         }
23     // Add LO to a learner AP
24     Insert_LO_in_AP(LO)
25     {
26         New LO Object in AP;
27         Learner.LO.Descriprion = LO;
28         Learner.LO.Status = "Desired";
29         Learner.LO.AchievedGrade = 0;
30         /* from LO-AE Algorithm1 get
31          the LO total weight grade in this course */
32         Learner.LO.Ref_Grade = Get_LO_Total_Grade_Weight(LO);
33     }
34     // Add LO to a learner AP
35     Update_LO_in_AP(LO)
36     {
37         Learner.LO.Status = "Desired";
38         // Append new LO Ref. Grade to the Previous Ref. Grade
39         Learner.LO.Ref_Grade = Learner.LO.Ref_Grade + Get_LO_Total_Grade_Weight(LO);
40     }

```

**Figure 15: LO-AT Algorithm (2)**

### 4.6.3 Assessment Grading State Algorithm (3)

This is the longest state in the course lifetime. The method `Update_LO_Achievement()` is invoked each time the instructor is finished from grading an assessment. Therefore, it keeps the AP updated with the latest achievements. This method is responsible for updating the *Assessment Records* element with date, evidence, assessing body and append the new LO achieved grade by calling LO-AE Algorithm2. Finally, this method changes the LO status to *Achieved* if it is greater or equal the success grade for the course.

```

LO-AT Algorithm 3: Update LOs Achievement for a Learner in AP
-----
1  // Update LO Achievements on Each Assessment Grading Process
2  Update_LO_Achievement(Assessment, LO)
3  {
4      Ref_Level = Learner.LO.Ref_Grade * 60%;
5      Foreach Grading Process DO:
6          {
7              Foreach Learner DO:
8                  {
9                      Learner.LO.AchievedGrade = Learner.LO.AchievedGrade +
10                     Get_LO_Achieved_Grade(Learner, Assessment, LO);
11                     New Evidence Object in LO;
12                     Learner.LO.Evidence.Date = Grading Date;
13                     Learner.LO.Evidence.Instructor = Instructor Name;
14                     Learner.LO.Evidence.ID = Assessment ID;
15                     IF(Learner.LO.AchievedGrade >= Ref_Level)
16                         {
17                             Learner.LO.Status = "Achieved";
18                         }
19                     ELSE
20                         {
21                             Learner.LO.Status = "Desired";
22                         }
23                 }
24             }
25         }

```

**Figure 16: LO-AT Algorithm (3)**

#### 4.6.4 Ending Course State Algorithm (4)

This is the last state. Once the semester is finished, the Archive\_LO\_Achievement Algorithm is responsible for archiving all LOs into their final status. It changes the LOs status to *Unachieved* if the total LO achieved grade is less than the success level.

```

LO-AT Algorithm 4: Archive All LOs to a Learner AP at the End of the Course
-----
1  // At the End of the Course
2  Archive_LO_Achievement(LO)
3  {
4      Ref_Level = Learner.LO.Ref_Grade * 60%;
5      Foreach Learner DO:
6          {
7              // if LO Ref Grade is 0, this means the LO not assessed.
8              IF(Learner.LO.Ref_Grade == 0)
9                  Learner.LO.Status = "Desired";
10             ELSE IF(Learner.LO.AchievedGrade < Ref_Level)
11                 Learner.LO.Status = "Unachieved";
12             }
13         }
14     }

```

**Figure 17: LO-AT Algorithm (4)**

## 4.7 DLP Schema

We discussed in the previous sections each component in DLP. Thus, in this section, we will analyze and design the DLP as a complete model. As described before, DLP consists of three modules, LO evaluation model, LO tracking module and LO achievement profile. Consequently, the DLP schema consists of the LO-AE and the LO-AP. And the LO-AT represents the dynamic interactions between the LO-AE and the LO-AP. As shown in Figure 18 below, LO-AE and LO-AP is linked together through three element classes. The first link is *Context element* is describing the educational context of *Achievements*, and it is described by *Courses element*. The second significant link is *Learning Outcomes element*. This element is a common element between for LO-AE and LO-AP, and it describes the LO that stored in the *Achievement element* and represent the LO that should be evaluated by *Question element*. The third link is between the *Assessment Records* and *Student Grades*. In this relationship, each *Assessment Records* has one or more *Student Grades* records which represent the total achieved grade for each LO in the *Achievement element*.

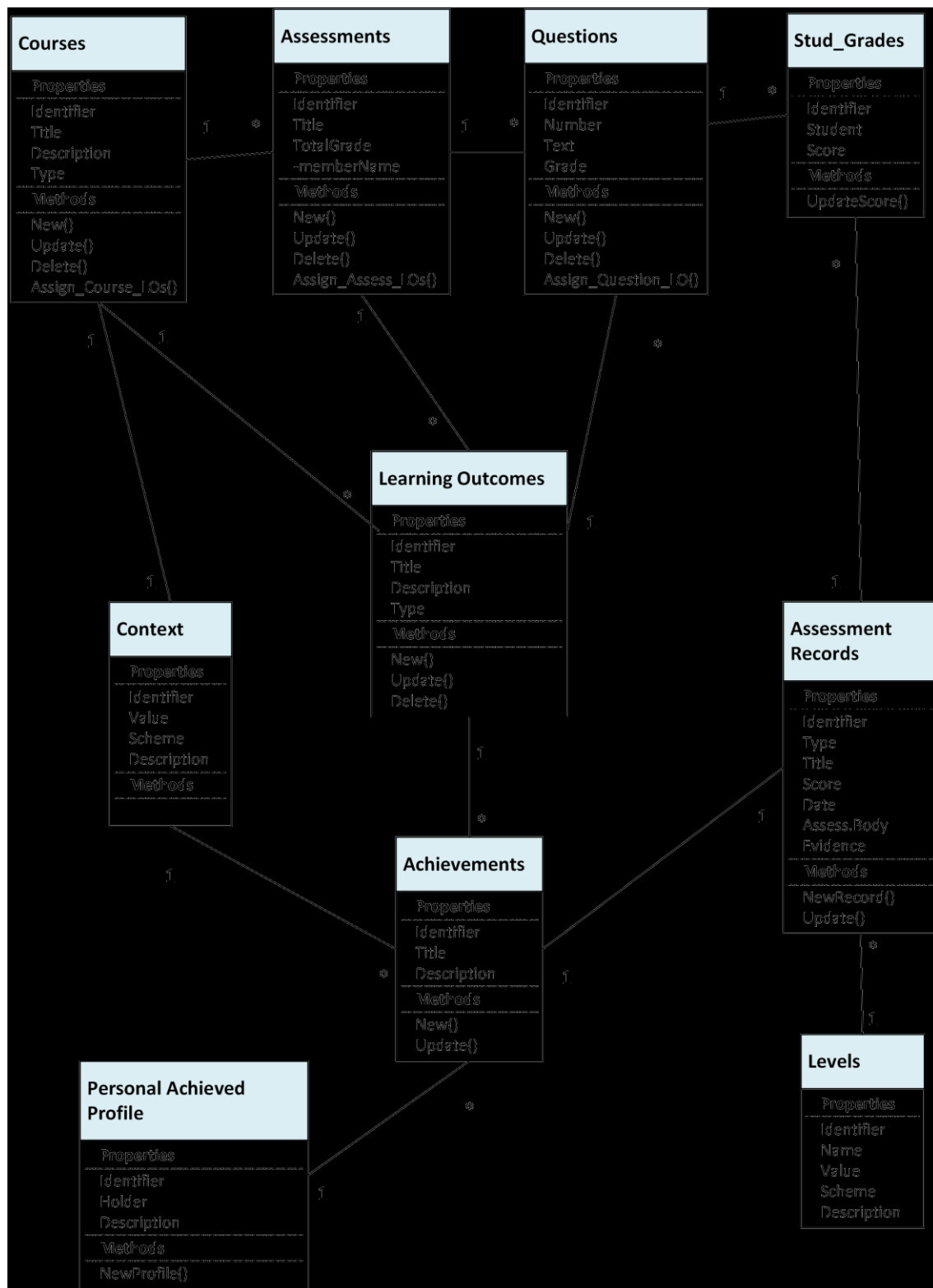
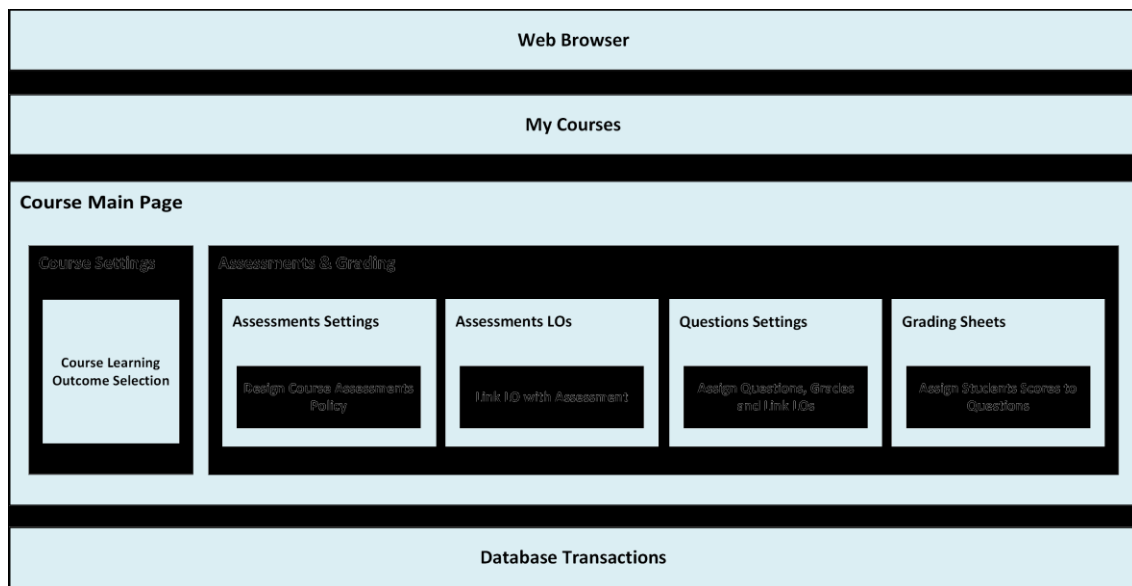


Figure 18: DLP Schema

## 4.7 DLP Architecture Layers

As mentioned in section 4.2, DLP is a reusable model and can be integrated with any legacy educational system, therefore, the architecture layering technique is applied to represent the model functionalities in separate layers. This layering technique is used to facilitate any future work to improve the model with new components. Moreover, it gives an abstraction for implementing the model screens and functionalities.



**Figure 19: The Architecture of DLP (Instructor View)**

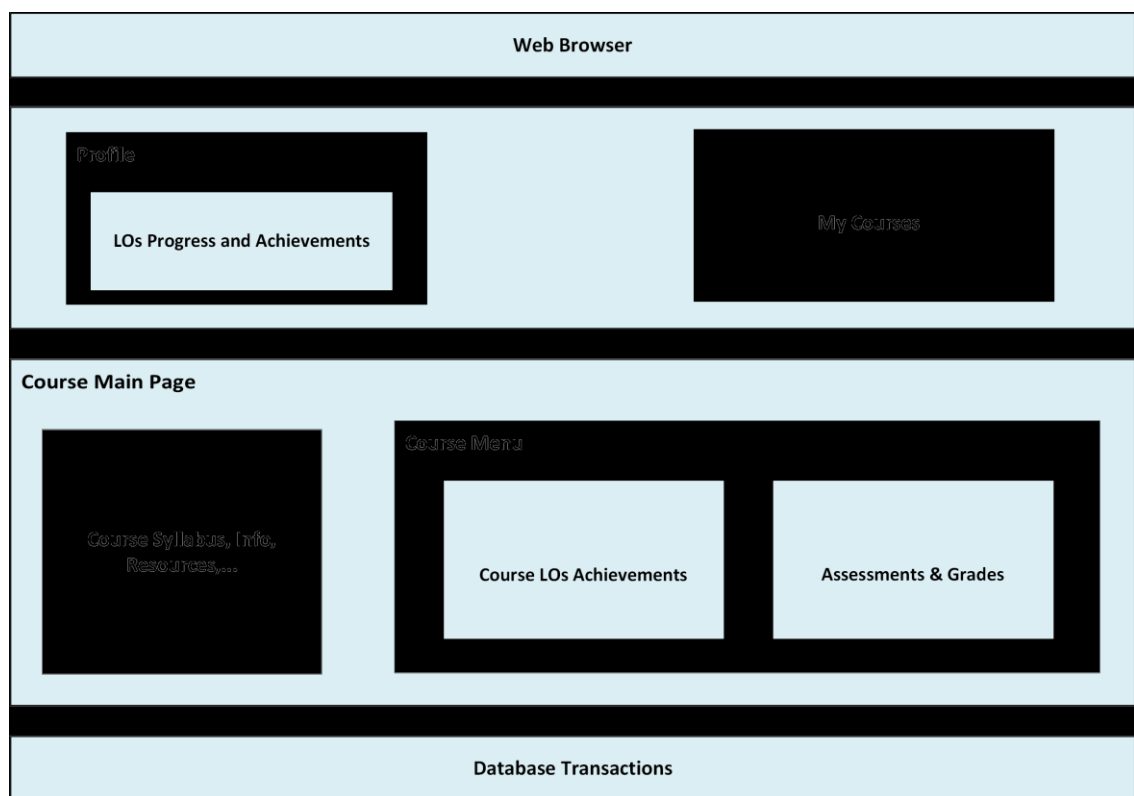
Figure 19, shown the four main layers of DLP model for the instructor view, the first layer is the user interface layer which is the web browser. The second one is My Courses layer, which contains all courses that taught by an instructor, and it's acting as the umbrella for all the lower functionalities.

The third layer is the LO-AE model. Firstly, it contains the course settings to assign the course LOs, secondly it contains the assessments and grading settings.

Assessments and grading settings consists of four important functionalities are responsible for generating the achieved LOs based formal assessments.

The database layer is the last layer, and it represents all the hidden transactions that occurs while accessing the upper layers.

The student view architecture is represented in figure 20 in four layers. The first and last layers are the same with the instructor architecture view. Conversely, the second and third layers are different. In the second layer, the student will be able to view courses and LO-AP to see the LOs achievements in all courses. The third layer is responsible for showing the students LOs progress and grades in a specific course.



**Figure 20: The Architecture of DLP (Student View)**

## **5. DLP SYSTEM IMPLEMENTATION**

### **5.1 Implementation**

In this Chapter, we will describe the implementation process that we went through to develop a proof of concept of the DLP model. Thus, it is developed using ASP.NET and MySQL through four stages. Firstly, database design, secondly, UI wireframing, thirdly, developing UIs and screens and finally applying algorithms and functionalities for the system.

### **5.2 Database Design and implementation**

Previously, in Chapter 4, we described the DLP classes and relationships and we described DLP Schema.

The DLP schema that described earlier in figure 18, actually it is an abstract version of the database Entity Relationship Diagram (ERD) that we will describe it in this section.

#### **5.2.1 Entity Relationship Diagram (ER)**

The ER is implemented for DLP model to illustrate the data tables and the relationship between them. The ER diagram shown in figure 21 consists of the DLP schema and the integration interface. This interface consists of a set of key data tables that should be exist in any legacy educational system, as mentioned in section 4.2. Now let's go deep with DB design process.

Firstly, we identified the transitive dependency constraints if it exists for each two tables have an association, then we split them into three data tables having the lossless-

join decomposition property. Then the transitive dependency holds for the relations that shown in Table 5 :

| Table1                 | Assoc.            | Table2                  | Splitted Relations                           |                   |                                                          |                   |                                        |
|------------------------|-------------------|-------------------------|----------------------------------------------|-------------------|----------------------------------------------------------|-------------------|----------------------------------------|
| Courses                | $1 \rightarrow *$ | Assessments             | courses                                      | $1 \rightarrow *$ | course_assess                                            | $* \rightarrow 1$ | assessments                            |
|                        |                   |                         | describe all courses in the system           |                   | Each course associated with 0,1 or * assess. records     |                   | describe all assessments in the system |
| Courses                | $1 \rightarrow *$ | Learning outcomes       | courses                                      | $1 \rightarrow *$ | course_learning_outcomes                                 | $* \rightarrow 1$ | Learning outcomes                      |
|                        |                   |                         | describe all courses in the system           |                   | Each course associated with 0,1 or * LO records.         |                   | describe all LOs in the system         |
| Assessments            | $1 \rightarrow *$ | Learning outcomes       | course_assess                                | $1 \rightarrow *$ | course_assess_learning_outcomes                          | $* \rightarrow 1$ | Learning outcomes                      |
|                        |                   |                         | Each assess. record associated with a course |                   | Each assess. Record associated with 0,1 or * LO records. |                   | describe all LOs in the system         |
| Learning outcomes.type | $1 \rightarrow *$ | Learning outcomes.title | Learning_outcomes                            | $* \rightarrow 1$ | Learning_outcomes_types                                  |                   |                                        |
|                        |                   |                         | LO records                                   |                   | Each LO type associated with 0,1 or * LO records.        |                   |                                        |

**Table 5: Transitive Dependency Relations**

Secondly, we identified the integration data tables based on the following needs:

- Users' data table: each registration system in any University has students' information such as registration numbers and names.
- Student Registered Courses data table: each registration system has students registered in courses.

Thirdly, we applied the relationships that described previously in the Class diagram in chapter 4.

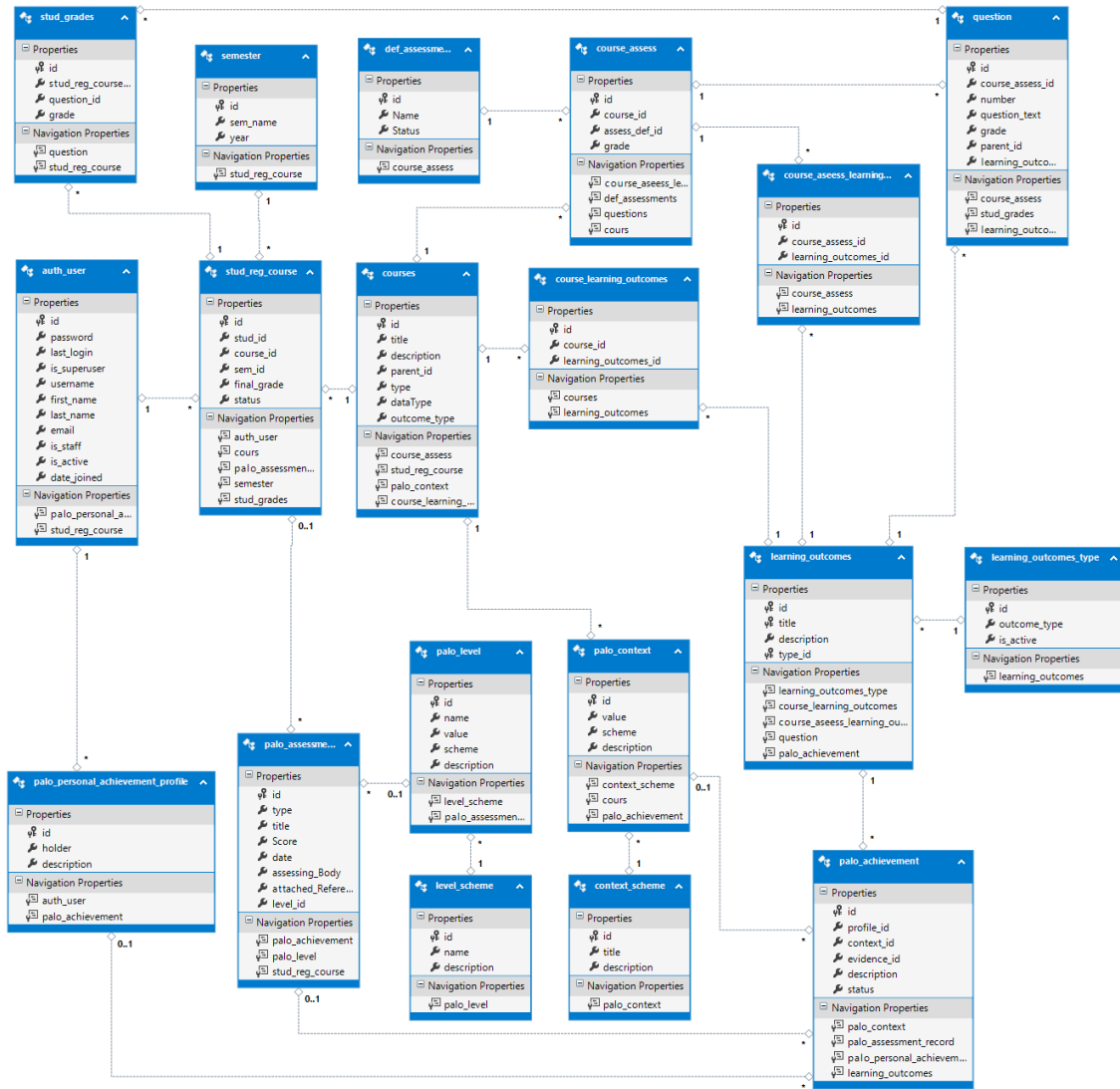


Figure 21: Entity Relationship Diagram

## 5.3 User Interface

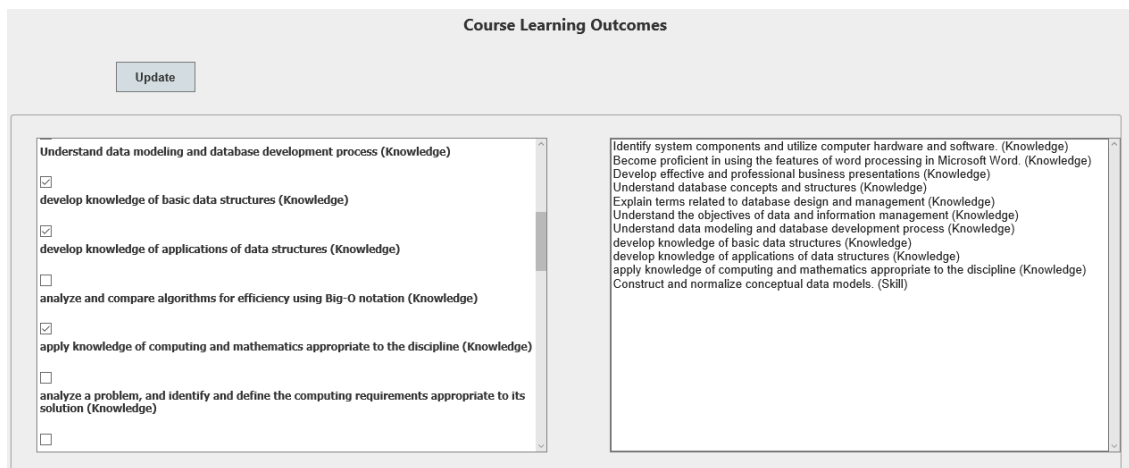
The user interface and screens are implemented based on the architecture layers that described before in chapter 4. Based on this, we implemented the following:

- Courses as shown in Figure 22, contains all registered courses for students / assigned for instructors.



**Figure 22: Courses Screen**

- Course Learning Outcomes as shown in Figure 23, this screen on the course main page and allows the instructors to assign the course LOs.



**Figure 23: Course Learning Outcomes Screen**

- Assessments Settings as shown in Figure 24, to assign the course assessment policy and grades.

**Algorithms and Complexity (AL)**

Assessment & Grading

Settings Outcomes Questions Grades

**Assessment Settings**

Assessment: Second Grade: 20

|        | id | Assessment | grade |
|--------|----|------------|-------|
| Select | 1  | Second     | 20    |
| Select | 2  | Project    | 20    |
| Select | 10 | First      | 20    |
| Select | 12 | Final      | 40    |
| Select | 13 | Mid        | 10    |

**Figure 24: Assessments Settings Screen**

- Assessments Outcomes as shown in Figure 25, to assign the LOs to be measured in each assessment.

**Algorithms and Complexity (AL)**

Assessment & Grading

Settings Outcomes Questions Grades

**Assessment Outcomes**

Assessment: First Grade: 20

- ☒ Understand database concepts and structures (Knowledge)
- ☒ Develop effective and professional business presentations (Knowledge)
- ☒ Explain terms related to database design and management (Knowledge)
- ☐ Understand the objectives of data and information management (Knowledge)
- ☐ Understand data modeling and database development process (Knowledge)
- ☐ develop knowledge of basic data structures (Knowledge)

**Figure 25: Assessments Outcomes Screen**

- Assessment Questions as shown in Figure 26, to create questions for each assessment, each question can be linked with a specific LO and has a grade.

**Assessment Questions**

---

Assessment 
Grade

---

Outcome

No.

Grade

New/Sub

What is the...

Question

Save New
Update
Delete

|        | id | number | question_text  | grade | parent_id | course_assess_id | learning_outcome_id |
|--------|----|--------|----------------|-------|-----------|------------------|---------------------|
| Select | 12 | Q1     | What is the... | 5     | 0         | 10               | 4                   |
| Select | 13 | Q2     | What is the... | 5     | 0         | 10               | 3                   |
| Select | 14 | Q3 - A | What is the... | 5     | 0         | 10               | 5                   |
| Select | 15 | Q3 - B | what is...     | 5     | 14        | 10               | 5                   |

**Figure 26: Assessments Questions Screen**

- Assessment Grading Sheet as shown in Figure 27, to assign scores for students based on their exam results.

Al-Quds University - ILT Project

[My Courses](#)
[Profile](#)

### Algorithms and Complexity (AL)

Assessment & Grading  
Settings Outcomes Questions Grades

**Grading Sheet**

Assessment 
Grade 
Refresh Student List
Refresh

|               | RegNo  | Stud_Name | Q1(5grade)                     | Q2(5grade)                     | Q3 - A(5grade)                 | Q3 - B(5grade)                 | Total |
|---------------|--------|-----------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|-------|
| Update Cancel | 111111 | baha      | <input type="text" value="5"/> | <input type="text" value="4"/> | <input type="text" value="3"/> | <input type="text" value="5"/> |       |
| Edit          | 55555  | Moh       | <input type="text" value="1"/> | <input type="text" value="2"/> | <input type="text" value="5"/> | <input type="text" value="0"/> |       |
| Edit          | 22222  | Murad     | <input type="text" value="5"/> | <input type="text" value="1"/> | <input type="text" value="5"/> | <input type="text" value="5"/> |       |
| Edit          | 33333  | Saleh     | <input type="text" value="5"/> | <input type="text" value="1"/> | <input type="text" value="5"/> | <input type="text" value="5"/> |       |
| Edit          | 44444  | Mohm      | <input type="text" value="2"/> | <input type="text" value="2"/> | <input type="text" value="1"/> | <input type="text" value="3"/> |       |

**Figure 27: Assessments Grading Sheet Screen**

## 6. TESTING AND RESULTS

### 6.1 Experiment

The experiment is conducted by testing the DLP model on existing marks for 9 students distributed on three courses. The courses were Computer Architecture as an experimental course with 3 random students, Biostatistics and Data Transmission courses from Al-Quds Open University with 6 real students marks as Shown below in Tables 6, 7 and 8.

| Computer Architecture and Organization Course, Student Results in all Assessments |                |                |     |     |     |     |     |     |                            |                      |
|-----------------------------------------------------------------------------------|----------------|----------------|-----|-----|-----|-----|-----|-----|----------------------------|----------------------|
| Student                                                                           | Assessments    | Question/Task  | LO1 | LO2 | LO3 | LO4 | LO5 | LO6 | Total Student Assessment % | Total Student Grade% |
| Ahmed                                                                             | Midterm<br>30% | Q1 (10 points) | 5   |     |     |     |     |     | 20%                        | 74%                  |
|                                                                                   |                | Q2 (10 points) |     | 8   |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 7   |     |     |     |                            |                      |
|                                                                                   | Final<br>40%   | Q1 (5 points)  | 3   |     |     |     |     |     | 33%                        |                      |
|                                                                                   |                | Q2 (5 points)  |     | 4   |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 7   |     |     |     |                            |                      |
|                                                                                   |                | Q4 (20 points) |     |     |     | 19  |     |     |                            |                      |
|                                                                                   | Project<br>30% | T1 (10 points) |     |     |     |     | 4   |     | 21%                        |                      |
| T2 (20 points)                                                                    |                |                |     |     |     |     | 17  |     |                            |                      |
| Lia                                                                               | Midterm<br>30% | Q1 (10 points) | 6   |     |     |     |     |     | 24%                        | 83%                  |
|                                                                                   |                | Q2 (10 points) |     | 9   |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 9   |     |     |     |                            |                      |
|                                                                                   | Final<br>40%   | Q1 (5 points)  | 4   |     |     |     |     |     | 36%                        |                      |
|                                                                                   |                | Q2 (5 points)  |     | 5   |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 8   |     |     |     |                            |                      |
|                                                                                   |                | Q4 (20 points) |     |     |     | 19  |     |     |                            |                      |
|                                                                                   | Project<br>30% | T1 (10 points) |     |     |     |     | 4   |     | 23%                        |                      |
| T2 (20 points)                                                                    |                |                |     |     |     |     | 19  |     |                            |                      |
| Leen                                                                              | Midterm<br>30% | Q1 (10 points) | 6   |     |     |     |     |     | 25%                        | 88%                  |
|                                                                                   |                | Q2 (10 points) |     | 10  |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 9   |     |     |     |                            |                      |
|                                                                                   | Final<br>40%   | Q1 (5 points)  | 4   |     |     |     |     |     | 37%                        |                      |
|                                                                                   |                | Q2 (5 points)  |     | 4   |     |     |     |     |                            |                      |
|                                                                                   |                | Q3 (10 points) |     |     | 10  |     |     |     |                            |                      |
|                                                                                   |                | Q4 (20 points) |     |     |     | 19  |     |     |                            |                      |
|                                                                                   | Project<br>30% | T1 (10 points) |     |     |     |     | 7   |     | 26%                        |                      |
| T2 (20 points)                                                                    |                |                |     |     |     |     | 19  |     |                            |                      |

Table 6: Computer Architecture and Organization Course, Students Result in all Assessments

| Data Transmission Course, Student Results in all Assessments |                |                     |     |     |     |     |                            |                      |
|--------------------------------------------------------------|----------------|---------------------|-----|-----|-----|-----|----------------------------|----------------------|
| Student                                                      | Assessments    | Question/Task       | LO1 | LO2 | LO3 | LO4 | Total Student Assessment % | Total Student Grade% |
| AhmedDT                                                      | Final<br>60%   | Q1 (7+5 points)     | 6   |     | 4   |     | 43%                        | 63%                  |
|                                                              |                | Q2 (5+2+7+4 points) | 4   | 1   | 5   | 4   |                            |                      |
|                                                              |                | Q3 (9 points)       | 5   |     |     |     |                            |                      |
|                                                              |                | Q4 (4+5 points)     | 1   |     | 4   |     |                            |                      |
|                                                              |                | Q5 (4+8 points)     |     | 3   |     | 6   |                            |                      |
|                                                              | Project<br>40% | T1(28 points)       | 12  |     |     |     | 20%                        |                      |
|                                                              |                | T2(12 points)       |     |     | 8   |     |                            |                      |
| Alaa                                                         | Final<br>60%   | Q1 (7+5 points)     | 2   |     | 1   |     | 36%                        | 52%                  |
|                                                              |                | Q2 (5+2+7+4 points) | 2   | 1   | 4   | 4   |                            |                      |
|                                                              |                | Q3 (9 points)       | 5   |     |     |     |                            |                      |
|                                                              |                | Q4 (4+5 points)     | 4   |     | 3   |     |                            |                      |
|                                                              |                | Q5 (4+8 points)     |     | 4   |     | 6   |                            |                      |
|                                                              | Project<br>40% | T1(28 points)       | 8   |     |     |     | 16%                        |                      |
|                                                              |                | T2(12 points)       |     |     | 8   |     |                            |                      |
| Mohammad                                                     | Final<br>60%   | Q1 (7+5 points)     | 5   |     | 3   |     | 34%                        | 54%                  |
|                                                              |                | Q2 (5+2+7+4 points) | 2   | 1   | 6   | 4   |                            |                      |
|                                                              |                | Q3 (9 points)       | 5   |     |     |     |                            |                      |
|                                                              |                | Q4 (4+5 points)     | 1   |     | 1   |     |                            |                      |
|                                                              |                | Q5 (4+8 points)     |     | 2   |     | 4   |                            |                      |
|                                                              | Project<br>40% | T1(28 points)       | 12  |     |     |     | 20%                        |                      |
|                                                              |                | T2(12 points)       |     |     | 8   |     |                            |                      |

**Table 7: Data Transmission Course, Students Result in all Assessments**

| Biostatistics Course, Student Results in all Assessments |                    |                      |            |            |            |                                   |                             |
|----------------------------------------------------------|--------------------|----------------------|------------|------------|------------|-----------------------------------|-----------------------------|
| <i>Student</i>                                           | <i>Assessments</i> | <i>Question/Task</i> | <i>LO1</i> | <i>LO2</i> | <i>LO3</i> | <i>Total Student Assessment %</i> | <i>Total Student Grade%</i> |
| Hanan                                                    | Final<br>100%      | Q1 (12+12+6 points)  | 12         | 9          | 3          | 85%                               | 85%                         |
|                                                          |                    | Q2 (18+12 points)    | 12         | 9          |            |                                   |                             |
|                                                          |                    | Q3 (20+20 points)    |            | 20         | 20         |                                   |                             |
| AhmadB                                                   | Final<br>100%      | Q1 (12+12+6 points)  | 11         | 12         | 6          | 99%                               | 99%                         |
|                                                          |                    | Q2 (18+12 points)    | 18         | 12         |            |                                   |                             |
|                                                          |                    | Q3 (20+20 points)    |            | 20         | 20         |                                   |                             |
| Madlin                                                   | Final<br>100%      | Q1 (12+12+6 points)  | 12         | 9          | 3          | 60%                               | 60%                         |
|                                                          |                    | Q2 (18+12 points)    | 3          | 3          |            |                                   |                             |
|                                                          |                    | Q3 (20+20 points)    |            | 16         | 14         |                                   |                             |

**Table 8: Data Transmission Course, Students Result in all Assessments**

The objective of this experiment is to proof that the DLP model is well designed and functioning correctly with all its components. And, the experiment is implemented using two tools, firstly, using the proof of concept DLP system that implemented in this

research to represent the results of DLP. Secondly, we applied the same data on MS Excel to validate the results of the DLP System.

Furthermore, the experiment performed through two phases: Assessment Design phase and DLP Creation phase. In the Assessment Design phase, the course LOs are selected and the assessment types are designed for all courses. Then, in the DLP Creation phase, we captured the dynamic behavior of the DLP for each student and the effect of grading assessments on each student LOs Achievements. Finally, we presented the LO Achievements for all students and we also provided an analysis.

## **6.2 Assessment Design Phase**

As described in section 6.1, in this phase we designed the courses with their assessments in the following steps:

### **6.2.1 Course LOs Selection**

We selected the LOs for each course as shown in Table 9.

| Computer Architecture and Organization Course LOs |                                                                               |           |
|---------------------------------------------------|-------------------------------------------------------------------------------|-----------|
| <b>LO1</b>                                        | Analyze the organisation of a computer system in terms of its main components | Knowledge |
| <b>LO2</b>                                        | Recognize the detailed operation of a simple microprocessor                   | Knowledge |
| <b>LO3</b>                                        | Compare the different processor architectures                                 | Knowledge |
| <b>LO4</b>                                        | Recognize the input/output mechanisms                                         | Knowledge |
| <b>LO5</b>                                        | Interface digital circuits to microprocessor systems                          | Skills    |
| <b>LO6</b>                                        | Design and analyze the main functional units of a computer.                   | Skills    |

| Biostatistics Course LOs |                                                                                                                                                  |           |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>LO1</b>               | Enable student to use deductive statistics and multiple types of estimators, explaining the meaning of point estimate and the interval estimate. | Knowledge |
| <b>LO2</b>               | Determine the parameters that are meant testing and choose the right test.                                                                       | Knowledge |
| <b>LO3</b>               | Conducting test hypotheses about the slope of the regression line, the constant and test hypotheses about the correlation coefficient.           | Knowledge |

| Data Transmission Course LOs |                                                                                     |           |
|------------------------------|-------------------------------------------------------------------------------------|-----------|
| <b>LO1</b>                   | Explain the principles of analog and digital signal conversion.                     | Knowledge |
| <b>LO2</b>                   | Recognize the principles of multiplexing and its techniques.                        | Knowledge |
| <b>LO3</b>                   | Discuss the main functionalities of digital modulation and demodulation techniques. | Knowledge |
| <b>LO4</b>                   | Determine the information types and the suitable coding techniques.                 | Knowledge |

**Table 9: Course Learning Outcomes**

## 6.2.2 LOs Total Grades

In this phase, we designed the assessments of each course based on the LO-AE Matrix by creating the assessments with grading weights such as Midterm 30%, Final 40% and Project 30%. Consequently, we selected and aligned the course LOs to each assessment. Questions with scores also created and aligned with the LOs of the assessment. And by the end of this phase, we produced a cumulative total grade for each LO which should be achieved by students.

In Table 10, the LO-AE Matrix shows mapping the course LOs with assessments and questions with a total grade for each LO using MS Excel. On the other hand, Figure 28, Figure 29 and Figure 30 shows the assessments design using the DLP system by setting up the LO-AE model.

| Computer Architecture and Organization Course, LO-AE Matrix |               |     |     |     |     |     |     |                             |
|-------------------------------------------------------------|---------------|-----|-----|-----|-----|-----|-----|-----------------------------|
| Assessments                                                 | Question/Task | LO1 | LO2 | LO3 | LO4 | LO5 | LO6 | Total Assessment Percentage |
| Midterm                                                     | Q1            | 10  |     |     |     |     |     | 30%                         |
|                                                             | Q2            |     | 10  |     |     |     |     |                             |
|                                                             | Q3            |     |     | 10  |     |     |     |                             |
| Final                                                       | Q1            | 5   |     |     |     |     |     | 40%                         |
|                                                             | Q2            |     | 5   |     |     |     |     |                             |
|                                                             | Q3            |     |     | 10  |     |     |     |                             |
|                                                             | Q4            |     |     |     | 20  |     |     |                             |
| Project                                                     | T1            |     |     |     |     | 10  |     | 30%                         |
|                                                             | T2            |     |     |     |     |     | 20  |                             |
| Total LO Percentage (T)                                     |               | 15% | 15% | 20% | 20% | 10% | 20% | 100%                        |

| Data Transmission Course, LO-AE Matrix |               |     |     |     |     |                             |
|----------------------------------------|---------------|-----|-----|-----|-----|-----------------------------|
| Assessments                            | Question/Task | LO1 | LO2 | LO3 | LO4 | Total Assessment Percentage |
| Final                                  | Q1            | 7   |     | 5   |     | 60%                         |
|                                        | Q2            | 5   | 2   | 7   | 4   |                             |
|                                        | Q3            | 9   |     |     |     |                             |
|                                        | Q4            | 4   |     | 5   |     |                             |
|                                        | Q5            |     | 4   |     | 8   |                             |
| Project                                | T1            | 28  |     |     |     | 40%                         |
|                                        | T2            |     |     | 12  |     |                             |
| Total LO Percentage (T)                |               | 53% | 6%  | 29% | 12% | 100%                        |

| Biostatistics Course, LO-AE Matrix |               |     |     |     |                             |
|------------------------------------|---------------|-----|-----|-----|-----------------------------|
| Assessments                        | Question/Task | LO1 | LO2 | LO3 | Total Assessment Percentage |
| Final (100)                        | Q1            | 12  | 12  | 6   | 100%                        |
|                                    | Q2            | 18  | 12  |     |                             |
|                                    | Q3            |     | 20  | 20  |                             |
| Total LO Percentage (T)            |               | 30% | 44% | 26% | 100%                        |

Table 10: MS Excel, LO-AE Matrix

**Computer Architecture and Organization (AR)**

Assessment & Grading

Settings Outcomes Questions Grades

**Assessment Settings**

Assessment First Grade

|        | id | Assessment | grade |
|--------|----|------------|-------|
| Select | 15 | Mid        | 30    |
| Select | 16 | Final      | 40    |
| Select | 18 | Project    | 30    |

© 2016 - ILT Application

**Data Transmission**

Assessment & Grading

Settings Outcomes Questions Grades

**Assessment Settings**

Assessment First Grade

|        | id | Assessment | grade |
|--------|----|------------|-------|
| Select | 19 | Final      | 60    |
| Select | 20 | Project    | 40    |

© 2017 - ILT Application

**Biostatistics**

Assessment & Grading

Settings Outcomes Questions Grades

**Assessment Settings**

Assessment First Grade

|        | id | Assessment | grade |
|--------|----|------------|-------|
| Select | 21 | Final      | 100   |

© 2017 - ILT Application

**Figure 28: DLP System, Assessment Creation Screens**

## Computer Architecture and Organization (AR)

Assessment & Grading

[Settings](#)
[Outcomes](#)
[Questions](#)
[Grades](#)

### Assessment Outcomes

Assessment

Mid

Grade

30

Update

☒

Analyze the organisation of a computer system in terms of its main components (Knowledge)

☒

Recognize the detailed operation of a simple microprocessor (Knowledge)

☒

Compare the different processor architectures (Knowledge)

☐

Recognize the input/output mechanisms (Knowledge)

☐

Interface digital circuits to microprocessor systems (Skills)

☐

Design and analyze the main functional units of a computer (Skills)

## Data Transmission

Assessment & Grading

[Settings](#)
[Outcomes](#)
[Questions](#)
[Grades](#)

### Assessment Outcomes

Assessment

Final

Grade

60

Update

☒

Explain the principles of analog and digital signal conversion. (Knowledge)

☒

Recognize the principles of multiplexing and its techniques. (Knowledge)

☒

Discuss the main functionalities of digital modulation and demodulation techniques. (Knowledge)

☒

Determine the information types and the suitable coding techniques. (Knowledge)

## Biostatistics

Assessment & Grading

[Settings](#)
[Outcomes](#)
[Questions](#)
[Grades](#)

### Assessment Outcomes

Assessment

Final

Grade

100

Update

☒

Enable student to use deductive statistics and multiple types of estimators, explaining the meaning of point estimate and the interval estimate (Knowledge)

☒

Determine the parameters that are meant testing and choose the right test (Knowledge)

☒

Conducting test hypotheses about the slope of the regression line, the constant and test hypotheses about the correlation coefficient (Knowledge)

**Figure 29: DLP System, Aligning LOs to Assessments Screens**

Computer Architecture and Organization (AR)

Assessment & Grading

Settings

Outcomes

Questions

Grades

Assessment Questions

Assessment

Mid

Grade

30

Outcome

Understand the organisation of a computer system in terms of its main comp

No.

Q1

Grade

10

New/Sub

New

Question

Save New

Update

Delete

|        | id | number | question_text | grade | parent_id | course_assess_id | learning_outcome_id |
|--------|----|--------|---------------|-------|-----------|------------------|---------------------|
| Select | 31 | Q1     |               | 10    | 0         | 15               | 41                  |
| Select | 32 | Q2     |               | 10    | 0         | 15               | 42                  |
| Select | 33 | Q3     |               | 10    | 0         | 15               | 43                  |

Data Transmission

Assessment & Grading

Settings

Outcomes

Questions

Grades

Assessment Questions

Assessment

Final

Grade

60

Outcome

Explain the principles of analog and digital signal conversion. (Knowledge)

No.

Grade

New/Sub

None

Question

Save New

Update

Delete

|        | id | number | question_text | grade | parent_id | course_assess_id | learning_outcome_id |
|--------|----|--------|---------------|-------|-----------|------------------|---------------------|
| Select | 42 | Q1-A   |               | 7     | 0         | 19               | 65                  |
| Select | 43 | Q1-B   |               | 5     | 0         | 19               | 67                  |
| Select | 44 | Q2-A   |               | 5     | 0         | 19               | 65                  |
| Select | 45 | Q2-B   |               | 2     | 0         | 19               | 66                  |
| Select | 46 | Q2-C   |               | 7     | 0         | 19               | 67                  |
| Select | 47 | Q2-D   |               | 4     | 0         | 19               | 68                  |
| Select | 48 | Q3     |               | 9     | 0         | 19               | 65                  |

Biostatistics

Assessment & Grading

Settings

Outcomes

Questions

Grades

Assessment Questions

Assessment

Final

Grade

100

Outcome

Enable student to use deductive statistics and multiple types of estimators, r

No.

Grade

New/Sub

None

Question

Save New

Update

Delete

|        | id | number | question_text | grade | parent_id | course_assess_id | learning_outcome_id |
|--------|----|--------|---------------|-------|-----------|------------------|---------------------|
| Select | 53 | Q1-A   |               | 12    | 0         | 21               | 62                  |
| Select | 54 | Q1-B   |               | 12    | 0         | 21               | 63                  |
| Select | 55 | Q1-C   |               | 6     | 0         | 21               | 64                  |
| Select | 58 | Q2-A   |               | 18    | 0         | 21               | 62                  |
| Select | 59 | Q2-B   |               | 12    | 0         | 21               | 63                  |

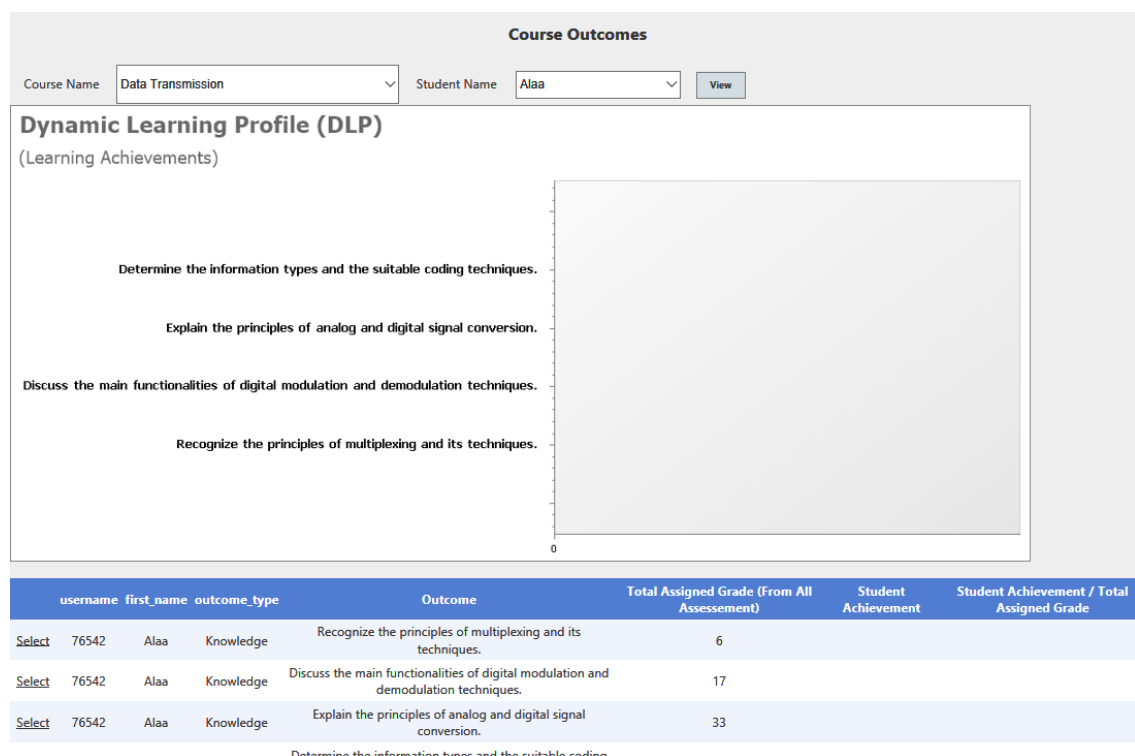
**Figure 30: DLP System, Aligning LOs to Questions with scores Screens**

## 6.3 DLP Creation Phase

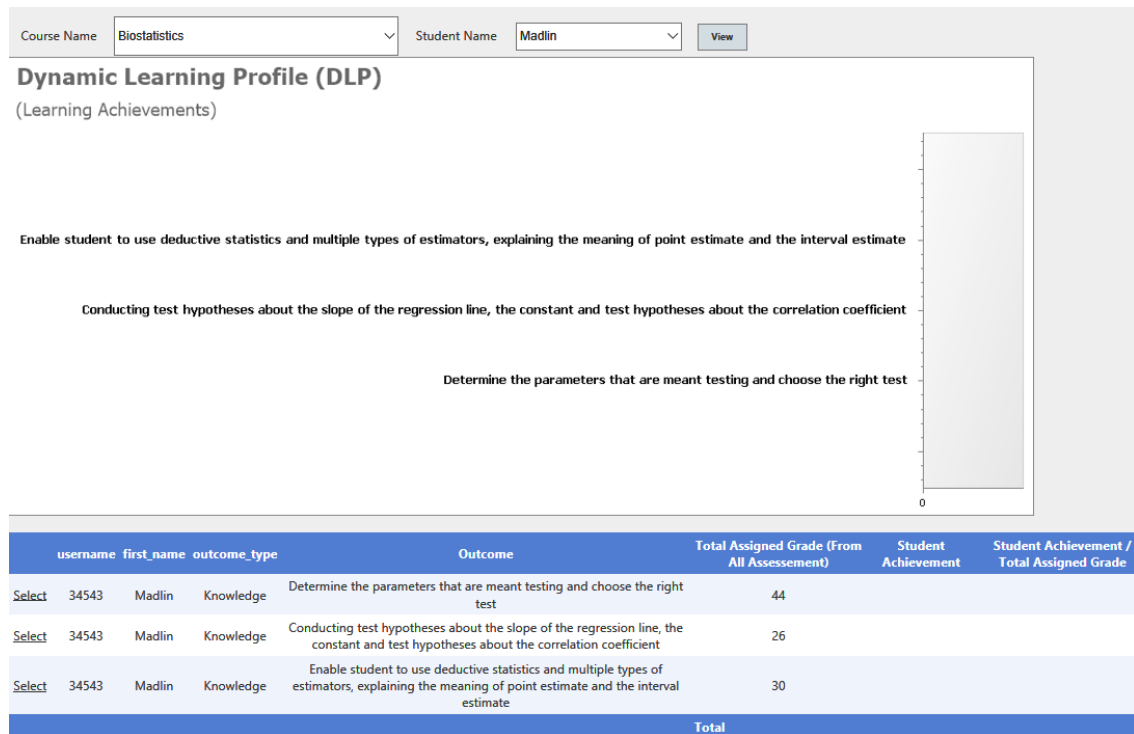
In this phase, we captured the dynamic behavior of the DLP through two states: The Initial state and the Grading State as shown in the following subsections.

### 6.3.1 DLP Initial State

When students attended a course, there are no LOs achievements in their DLPs as shown in Figures (31 and 32).



**Figure 31: DLP System, Alaa DLP when she attended the course Data Transmission**



**Figure 32: DLP System, Madlin DLP when she has attended the course**

## **Biostatistics**

### **6.3.2 DLP in Grading State**

In this State, DLP for each student will be updated dynamically after each grading process by teachers. And as shown below the results for each student.

#### **6.3.2.1 CAO Course**

This course has three students Ahmed, Lia and Leen, with three assessments: Midterm 30%, Final 40%, and Project 30% as shown in Figure 33.

| Computer Architecture and Organization (AR)                                                        |       |           |             |                      |             |       |
|----------------------------------------------------------------------------------------------------|-------|-----------|-------------|----------------------|-------------|-------|
| Assessment & Grading                                                                               |       |           |             |                      |             |       |
| <a href="#">Settings</a> <a href="#">Outcomes</a> <a href="#">Questions</a> <a href="#">Grades</a> |       |           |             |                      |             |       |
| Grading Sheet                                                                                      |       |           |             |                      |             |       |
| Assessment                                                                                         | Mid   | Grade     | 30          | Refresh Student List | Refresh     |       |
|                                                                                                    | RegNo | Stud_Name | Q1(10grade) | Q2(10grade)          | Q3(10grade) | Total |
| <a href="#">Edit</a>                                                                               | 12345 | Ahmed     | 5           | 8                    | 7           |       |
| <a href="#">Edit</a>                                                                               | 56789 | Lia       | 6           | 9                    | 9           |       |
| <a href="#">Edit</a>                                                                               | 34567 | Leen      | 6           | 10                   | 9           |       |

| Computer Architecture and Organization (AR)                                                        |       |           |            |                      |             |       |
|----------------------------------------------------------------------------------------------------|-------|-----------|------------|----------------------|-------------|-------|
| Assessment & Grading                                                                               |       |           |            |                      |             |       |
| <a href="#">Settings</a> <a href="#">Outcomes</a> <a href="#">Questions</a> <a href="#">Grades</a> |       |           |            |                      |             |       |
| Grading Sheet                                                                                      |       |           |            |                      |             |       |
| Assessment                                                                                         | Final | Grade     | 40         | Refresh Student List | Refresh     |       |
|                                                                                                    | RegNo | Stud_Name | Q1(5grade) | Q2(5grade)           | Q3(10grade) | Total |
| <a href="#">Edit</a>                                                                               | 12345 | Ahmed     | 3          | 4                    | 7           | 19    |
| <a href="#">Edit</a>                                                                               | 56789 | Lia       | 4          | 5                    | 8           | 19    |
| <a href="#">Edit</a>                                                                               | 34567 | Leen      | 4          | 4                    | 10          | 19    |

| Computer Architecture and Organization (AR)                                                        |         |           |                |                      |         |
|----------------------------------------------------------------------------------------------------|---------|-----------|----------------|----------------------|---------|
| Assessment & Grading                                                                               |         |           |                |                      |         |
| <a href="#">Settings</a> <a href="#">Outcomes</a> <a href="#">Questions</a> <a href="#">Grades</a> |         |           |                |                      |         |
| Grading Sheet                                                                                      |         |           |                |                      |         |
| Assessment                                                                                         | Project | Grade     | 30             | Refresh Student List | Refresh |
|                                                                                                    | RegNo   | Stud_Name | Task1(10grade) | Task2(20grade)       | Total   |
| <a href="#">Edit</a>                                                                               | 12345   | Ahmed     | 4              | 17                   |         |
| <a href="#">Edit</a>                                                                               | 56789   | Lia       | 4              | 19                   |         |
| <a href="#">Edit</a>                                                                               | 34567   | Leen      | 7              | 19                   |         |

**Figure 33: DLP System, Grading Midterm, Final, and Project Exams respectively**

**Students DLPs:**

**1- Ahmed**

| Ahmed                                                                                                                          | Computer Architecture and Organization Course, LO-AE Matrix |               |         |         |         |         |         |     |                          |                             |
|--------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------|---------|---------|---------|---------|---------|-----|--------------------------|-----------------------------|
|                                                                                                                                | Assessments                                                 | Question/Task | LO1     | LO2     | LO3     | LO4     | LO5     | LO6 | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                                | Midterm                                                     | Q1            | 5       |         |         |         |         |     | 20%                      | 30%                         |
|                                                                                                                                |                                                             | Q2            |         | 8       |         |         |         |     |                          |                             |
|                                                                                                                                |                                                             | Q3            |         |         | 7       |         |         |     |                          |                             |
|                                                                                                                                | Final                                                       | Q1            |         |         |         |         |         |     | 0%                       | 40%                         |
|                                                                                                                                |                                                             | Q2            |         |         |         |         |         |     |                          |                             |
|                                                                                                                                |                                                             | Q3            |         |         |         |         |         |     |                          |                             |
|                                                                                                                                |                                                             | Q4            |         |         |         |         |         |     |                          |                             |
|                                                                                                                                | Project                                                     | T1            |         |         |         |         |         |     | 0%                       | 30%                         |
|                                                                                                                                |                                                             | T2            |         |         |         |         |         |     |                          |                             |
|                                                                                                                                | Total Student Percentage(S)                                 |               | 5%      | 8%      | 7%      | 0%      | 0%      | 0%  | 20%                      | 100%                        |
| Total LO Percentage(T)                                                                                                         |                                                             | 15%           | 15%     | 20%     | 20%     | 10%     | 20%     |     |                          |                             |
| Student LO Achievement Percentage(S/T)                                                                                         |                                                             | 33%           | 53%     | 35%     | 0%      | 0%      | 0%      |     |                          |                             |
| Student LO Achievement Status                                                                                                  |                                                             | Desired       | Desired | Desired | Desired | Desired | Desired |     |                          |                             |
| Achieved = if (S/T) >= 60%         Desired = if (S/T) < 60%         Unachieved = if (S/T) < 60% AND all assessments are graded |                                                             |               |         |         |         |         |         |     |                          |                             |

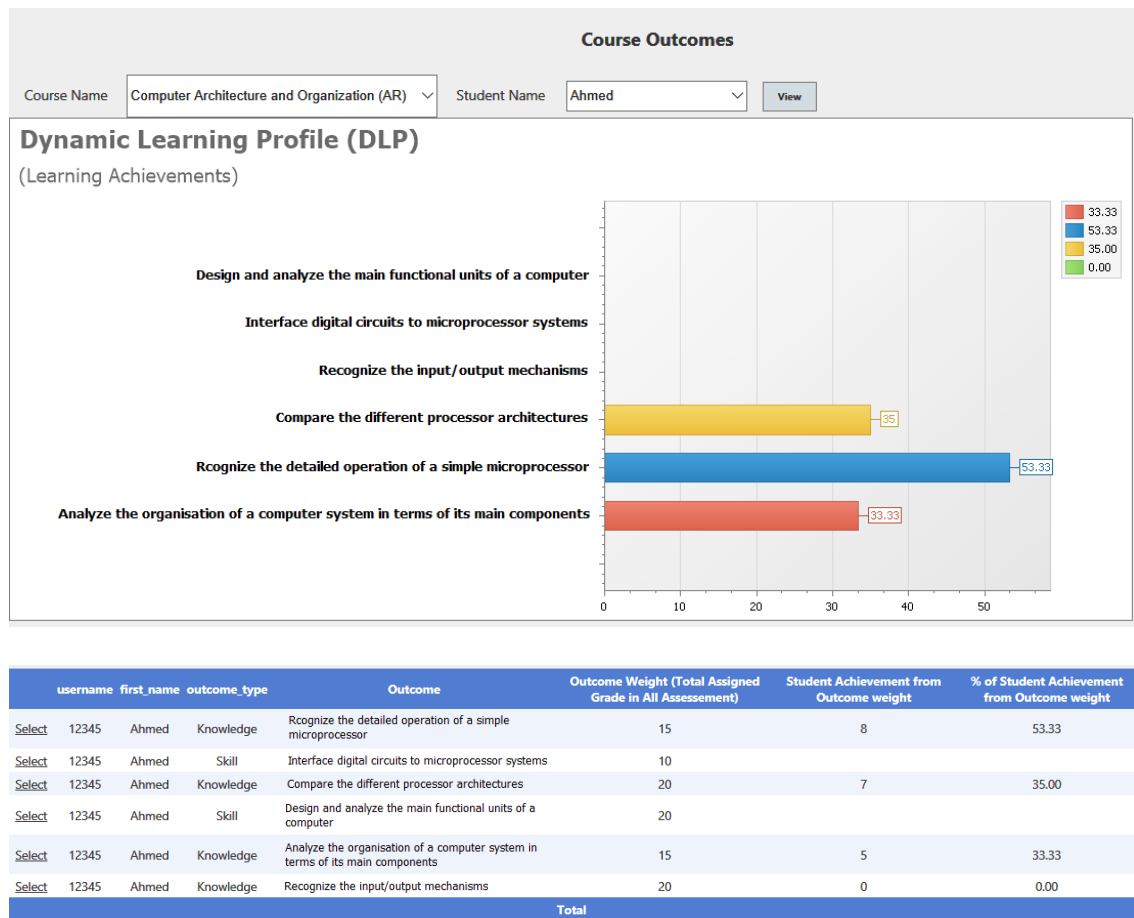
| Ahmed                                  | Computer Architecture and Organization Course, LO-AE Matrix |               |         |          |          |          |         |         |                          |                             |
|----------------------------------------|-------------------------------------------------------------|---------------|---------|----------|----------|----------|---------|---------|--------------------------|-----------------------------|
|                                        | Assessments                                                 | Question/Task | LO1     | LO2      | LO3      | LO4      | LO5     | LO6     | Total Student Percentage | Total Assessment Percentage |
|                                        | Midterm                                                     | Q1            | 5       |          |          |          |         |         | 20%                      | 30%                         |
|                                        |                                                             | Q2            |         | 8        |          |          |         |         |                          |                             |
|                                        |                                                             | Q3            |         |          | 7        |          |         |         |                          |                             |
|                                        | Final                                                       | Q1            | 3       |          |          |          |         |         | 33%                      | 40%                         |
|                                        |                                                             | Q2            |         | 4        |          |          |         |         |                          |                             |
|                                        |                                                             | Q3            |         |          | 7        |          |         |         |                          |                             |
|                                        |                                                             | Q4            |         |          |          | 19       |         |         |                          |                             |
|                                        | Project                                                     | T1            |         |          |          |          |         |         | 0%                       | 30%                         |
| T2                                     |                                                             |               |         |          |          |          |         |         |                          |                             |
| Total Student Percentage(S)            |                                                             |               | 8%      | 12%      | 14%      | 19%      | 0%      | 0%      | 53%                      | 100%                        |
| Total LO Percentage(T)                 |                                                             |               | 15%     | 15%      | 20%      | 20%      | 10%     | 20%     |                          |                             |
| Student LO Achievement Percentage(S/T) |                                                             |               | 53%     | 80%      | 70%      | 95%      | 0%      | 0%      |                          |                             |
| Student LO Achievement Status          |                                                             |               | Desired | Achieved | Achieved | Achieved | Desired | Desired |                          |                             |

Achieved = if (S/T) >= 60% | Desired = if (S/T) < 60% | Unachieved = if (S/T) < 60% AND all assessments are graded

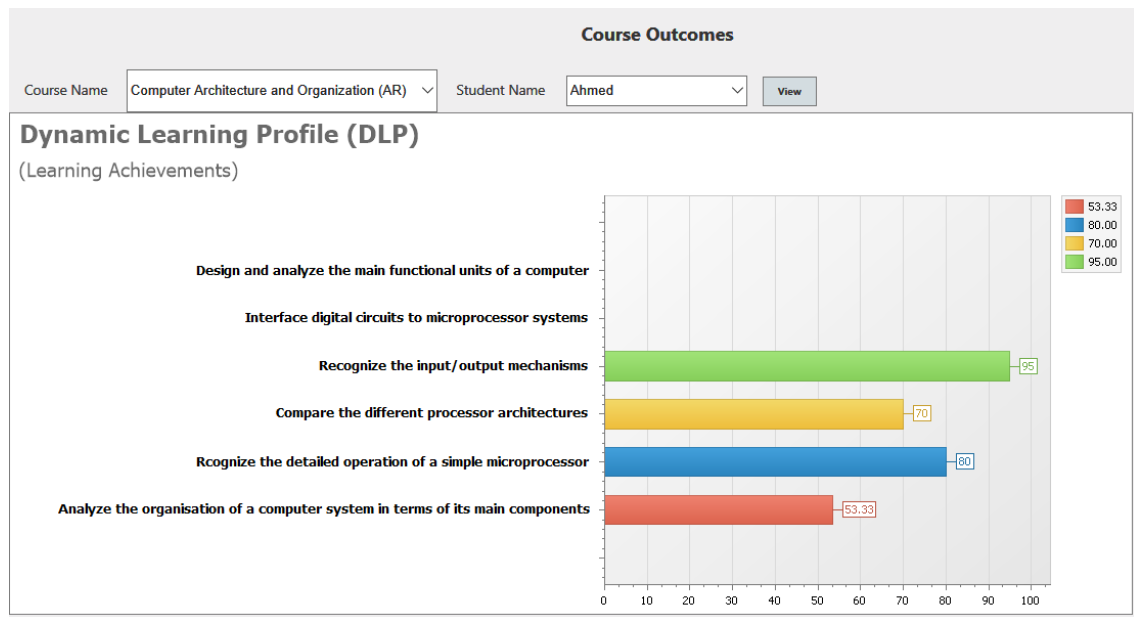
| Ahmed                                  | Computer Architecture and Organization Course, LO-AE Matrix |               |          |          |          |            |          |     |                          |                             |
|----------------------------------------|-------------------------------------------------------------|---------------|----------|----------|----------|------------|----------|-----|--------------------------|-----------------------------|
|                                        | Assessments                                                 | Question/Task | LO1      | LO2      | LO3      | LO4        | LO5      | LO6 | Total Student Percentage | Total Assessment Percentage |
|                                        | Midterm                                                     | Q1            | 5        |          |          |            |          |     | 20%                      | 30%                         |
|                                        |                                                             | Q2            |          | 8        |          |            |          |     |                          |                             |
|                                        |                                                             | Q3            |          |          | 7        |            |          |     |                          |                             |
|                                        | Final                                                       | Q1            | 3        |          |          |            |          |     | 33%                      | 40%                         |
|                                        |                                                             | Q2            |          | 4        |          |            |          |     |                          |                             |
|                                        |                                                             | Q3            |          |          | 7        |            |          |     |                          |                             |
|                                        |                                                             | Q4            |          |          |          | 19         |          |     |                          |                             |
|                                        | Project                                                     | T1            |          |          |          |            | 4        |     | 21%                      | 30%                         |
| T2                                     |                                                             |               |          |          |          |            | 17       |     |                          |                             |
| Total Student Percentage(S)            |                                                             | 8%            | 12%      | 14%      | 19%      | 4%         | 17%      | 74% | 100%                     |                             |
| Total LO Percentage(T)                 |                                                             | 15%           | 15%      | 20%      | 20%      | 10%        | 20%      |     |                          |                             |
| Student LO Achievement Percentage(S/T) |                                                             | 53%           | 80%      | 70%      | 95%      | 40%        | 85%      |     |                          |                             |
| Student LO Achievement Status          |                                                             | Unachieved    | Achieved | Achieved | Achieved | Unachieved | Achieved |     |                          |                             |

Achieved = if (S/T) >= 60% | Desired = if (S/T) < 60% | Unachieved = if (S/T) < 60% AND all assessments are graded

**Table 11: MS Excel, Ahmed Achievements after each exam grading**

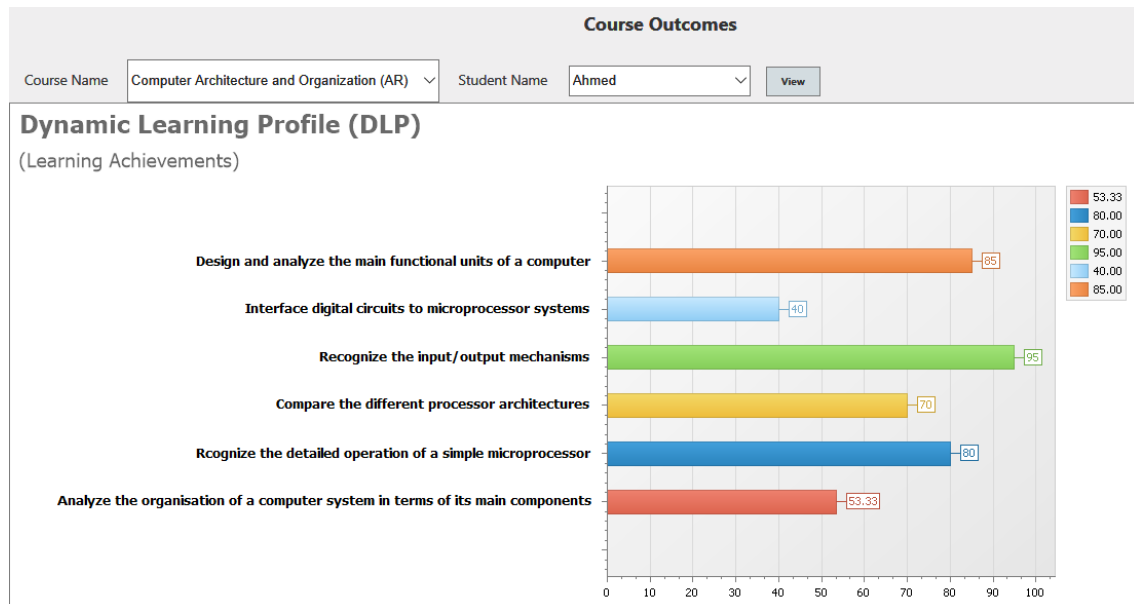


**Figure 34: DLP System, Ahmed DLP and achievements after grading midterm exam**



| username               | first_name | outcome_type | Outcome   | Outcome Weight (Total Assigned Grade in All Assessment)                       | Student Achievement from Outcome weight | % of Student Achievement from Outcome weight |       |
|------------------------|------------|--------------|-----------|-------------------------------------------------------------------------------|-----------------------------------------|----------------------------------------------|-------|
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Recognize the detailed operation of a simple microprocessor                   | 15                                      | 12                                           | 80.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Skill     | Interface digital circuits to microprocessor systems                          | 10                                      |                                              |       |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Compare the different processor architectures                                 | 20                                      | 14                                           | 70.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Skill     | Design and analyze the main functional units of a computer                    | 20                                      |                                              |       |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Analyze the organisation of a computer system in terms of its main components | 15                                      | 8                                            | 53.33 |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Recognize the input/output mechanisms                                         | 20                                      | 19                                           | 95.00 |
| Total                  |            |              |           |                                                                               |                                         |                                              |       |

**Figure 35: DLP System, Ahmed DLP and achievements after grading final exam**



| username               | first_name | outcome_type | Outcome   | Outcome Weight (Total Assigned Grade in All Assessment)                       | Student Achievement from Outcome weight | % of Student Achievement from Outcome weight |       |
|------------------------|------------|--------------|-----------|-------------------------------------------------------------------------------|-----------------------------------------|----------------------------------------------|-------|
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Recognize the detailed operation of a simple microprocessor                   | 15                                      | 12                                           | 80.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Skill     | Interface digital circuits to microprocessor systems                          | 10                                      | 4                                            | 40.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Compare the different processor architectures                                 | 20                                      | 14                                           | 70.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Skill     | Design and analyze the main functional units of a computer                    | 20                                      | 17                                           | 85.00 |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Analyze the organisation of a computer system in terms of its main components | 15                                      | 8                                            | 53.33 |
| <a href="#">Select</a> | 12345      | Ahmed        | Knowledge | Recognize the input/output mechanisms                                         | 20                                      | 19                                           | 95.00 |
| Total                  |            |              |           |                                                                               |                                         |                                              |       |

**Figure 36: DLP System, Ahmed DLP and achievements after grading project**

Course Assessments

Course Name

Computer Architecture and Organ

Student Name

Ahmed

View

course\_assess\_id

learning\_outcome\_id

outcome\_type

stud\_grade

assess\_name

assess\_grade

questions

question\_grade

| lo_title                                                                      | Final |    |    |    | Mid |    |    | Project |       | Grand Total |
|-------------------------------------------------------------------------------|-------|----|----|----|-----|----|----|---------|-------|-------------|
|                                                                               | 40    |    |    |    | 30  |    |    | 30      |       |             |
|                                                                               | Q1    | Q2 | Q3 | Q4 | Q1  | Q2 | Q3 | Task1   | Task2 |             |
| Design and analyze the main functional units of a computer                    | 5     | 5  | 10 | 20 | 10  | 10 | 10 | 10      | 20    | 17          |
| Interface digital circuits to microprocessor systems                          |       |    |    |    |     |    |    | 4       |       | 4           |
| Compare the different processor architectures                                 |       |    | 7  |    |     |    | 7  |         |       | 14          |
| Recognize the input/output mechanisms                                         |       |    |    | 19 |     |    |    |         |       | 19          |
| Recognize the detailed operation of a simple microprocessor                   |       | 4  |    |    |     | 8  |    |         |       | 12          |
| Analyze the organisation of a computer system in terms of its main components | 3     |    |    |    | 5   |    |    |         |       | 8           |
| Grand Total                                                                   | 3     | 4  | 7  | 19 | 5   | 8  | 7  | 4       | 17    | 74          |

**Figure 37: DLP System, Ahmed Matrix Grades (LO, Exam, Grade)**

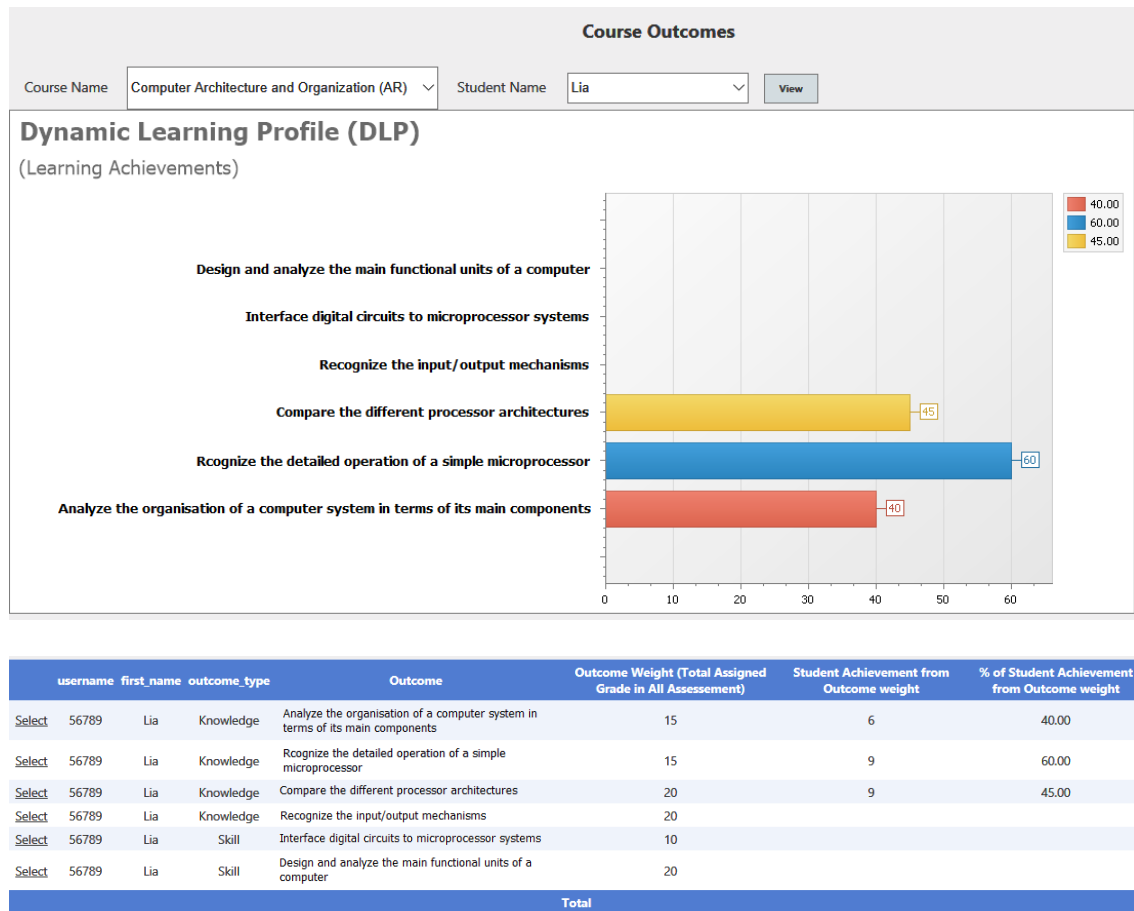
| Lia                                                                                                                                    | Computer Architecture and Organization Course, LO-AE Matrix |               |         |          |         |         |         |         |                          |                             |
|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------|---------|----------|---------|---------|---------|---------|--------------------------|-----------------------------|
|                                                                                                                                        | Assessments                                                 | Question/Task | LO1     | LO2      | LO3     | LO4     | LO5     | LO6     | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                                        | Midterm                                                     | Q1            | 6       |          |         |         |         |         | 24%                      | 30%                         |
|                                                                                                                                        |                                                             | Q2            |         | 9        |         |         |         |         |                          |                             |
|                                                                                                                                        |                                                             | Q3            |         |          | 9       |         |         |         |                          |                             |
|                                                                                                                                        | Final                                                       | Q1            |         |          |         |         |         |         | 0%                       | 40%                         |
|                                                                                                                                        |                                                             | Q2            |         |          |         |         |         |         |                          |                             |
|                                                                                                                                        |                                                             | Q3            |         |          |         |         |         |         |                          |                             |
|                                                                                                                                        |                                                             | Q4            |         |          |         |         |         |         |                          |                             |
|                                                                                                                                        | Project                                                     | T1            |         |          |         |         |         |         | 0%                       | 30%                         |
| T2                                                                                                                                     |                                                             |               |         |          |         |         |         |         |                          |                             |
| Total Student Percentage(S)                                                                                                            |                                                             |               | 6%      | 9%       | 9%      | 0%      | 0%      | 0%      | 24%                      | 100%                        |
| Total LO Percentage(T)                                                                                                                 |                                                             |               | 15%     | 15%      | 20%     | 20%     | 10%     | 20%     |                          |                             |
| Student LO Achievement Percentage(S/T)                                                                                                 |                                                             |               | 40%     | 60%      | 45%     | 0%      | 0%      | 0%      |                          |                             |
|                                                                                                                                        | Student LO Achievement Status                               |               | Desired | Achieved | Desired | Desired | Desired | Desired |                          |                             |
| Achieved = if (S/T) >= 60%             Desired = if (S/T) < 60%             Unachieved = if (S/T) < 60% AND all assessments are graded |                                                             |               |         |          |         |         |         |         |                          |                             |

| Lia                                                                                                                                | Computer Architecture and Organization Course, LO-AE Matrix |               |          |          |          |         |         |     |                          |                             |
|------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------|----------|----------|----------|---------|---------|-----|--------------------------|-----------------------------|
|                                                                                                                                    | Assessments                                                 | Question/Task | LO1      | LO2      | LO3      | LO4     | LO5     | LO6 | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                                    | Midterm                                                     | Q1            | 6        |          |          |         |         |     | 24%                      | 30%                         |
|                                                                                                                                    |                                                             | Q2            |          | 9        |          |         |         |     |                          |                             |
|                                                                                                                                    |                                                             | Q3            |          |          | 9        |         |         |     |                          |                             |
|                                                                                                                                    | Final                                                       | Q1            | 4        |          |          |         |         |     | 36%                      | 40%                         |
|                                                                                                                                    |                                                             | Q2            |          | 5        |          |         |         |     |                          |                             |
|                                                                                                                                    |                                                             | Q3            |          |          | 8        |         |         |     |                          |                             |
|                                                                                                                                    |                                                             | Q4            |          |          |          | 19      |         |     |                          |                             |
|                                                                                                                                    | Project                                                     | T1            |          |          |          |         |         |     | 0%                       | 30%                         |
| T2                                                                                                                                 |                                                             |               |          |          |          |         |         |     |                          |                             |
| Total Student Percentage(S)                                                                                                        |                                                             | 10%           | 14%      | 17%      | 19%      | 0%      | 0%      | 60% | 100%                     |                             |
| Total LO Percentage(T)                                                                                                             |                                                             | 15%           | 15%      | 20%      | 20%      | 10%     | 20%     |     |                          |                             |
| Student LO Achievement Percentage(S/T)                                                                                             |                                                             | 67%           | 93%      | 85%      | 95%      | 0%      | 0%      |     |                          |                             |
| Student LO Achievement Status                                                                                                      |                                                             | Achieved      | Achieved | Achieved | Achieved | Desired | Desired |     |                          |                             |
| Achieved = if (S/T) >= 60%           Desired = if (S/T) < 60%           Unachieved = if (S/T) < 60% AND all assessments are graded |                                                             |               |          |          |          |         |         |     |                          |                             |

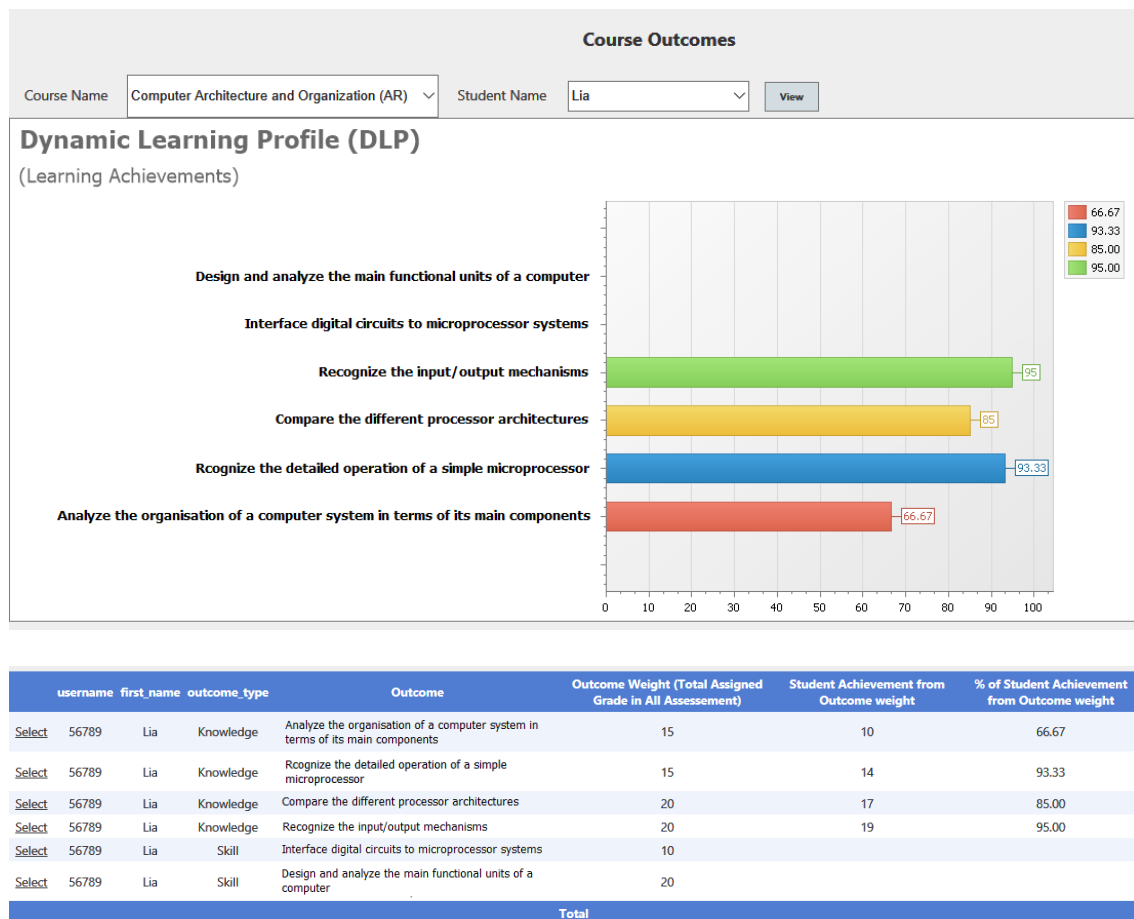
| Lia                                    | Computer Architecture and Organization Course, LO-AE Matrix |               |          |          |          |            |          |     |                          |                             |
|----------------------------------------|-------------------------------------------------------------|---------------|----------|----------|----------|------------|----------|-----|--------------------------|-----------------------------|
|                                        | Assessments                                                 | Question/Task | LO1      | LO2      | LO3      | LO4        | LO5      | LO6 | Total Student Percentage | Total Assessment Percentage |
|                                        | Midterm                                                     | Q1            | 6        |          |          |            |          |     | 24%                      | 30%                         |
|                                        |                                                             | Q2            |          | 9        |          |            |          |     |                          |                             |
|                                        |                                                             | Q3            |          |          | 9        |            |          |     |                          |                             |
|                                        | Final                                                       | Q1            | 4        |          |          |            |          |     | 36%                      | 40%                         |
|                                        |                                                             | Q2            |          | 5        |          |            |          |     |                          |                             |
|                                        |                                                             | Q3            |          |          | 8        |            |          |     |                          |                             |
|                                        |                                                             | Q4            |          |          |          | 19         |          |     |                          |                             |
|                                        | Project                                                     | T1            |          |          |          |            | 4        |     | 23%                      | 30%                         |
| T2                                     |                                                             |               |          |          |          |            | 19       |     |                          |                             |
| Total Student Percentage(S)            |                                                             | 10%           | 14%      | 17%      | 19%      | 4%         | 19%      | 83% | 100%                     |                             |
| Total LO Percentage(T)                 |                                                             | 15%           | 15%      | 20%      | 20%      | 10%        | 20%      |     |                          |                             |
| Student LO Achievement Percentage(S/T) |                                                             | 67%           | 93%      | 85%      | 95%      | 40%        | 95%      |     |                          |                             |
| Student LO Achievement Status          |                                                             | Achieved      | Achieved | Achieved | Achieved | Unachieved | Achieved |     |                          |                             |

Achieved = if (S/T) >= 60% | Desired = if (S/T) < 60% | Unachieved = if (S/T) < 60% AND all assessments are graded

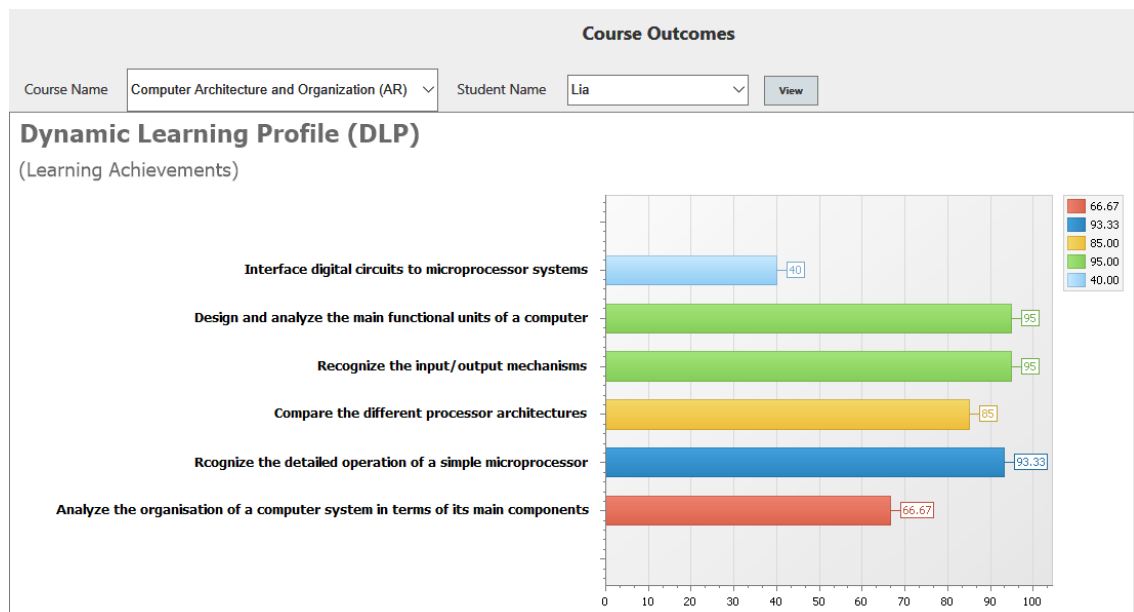
**Table 12: MS Excel, Lia Achievements after each exam grading**



**Figure 38: DLP System, Lia DLP and achievements after grading midterm exam**



**Figure 39: DLP System, Lia DLP and achievements after grading final exam**



|        | username | first_name | outcome_type | Outcome                                                                       | Outcome Weight (Total Assigned Grade in All Assessment) | Student Achievement from Outcome weight | % of Student Achievement from Outcome weight |
|--------|----------|------------|--------------|-------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------|----------------------------------------------|
| Select | 56789    | Lia        | Knowledge    | Analyze the organisation of a computer system in terms of its main components | 15                                                      | 10                                      | 66.67                                        |
| Select | 56789    | Lia        | Knowledge    | Recognize the detailed operation of a simple microprocessor                   | 15                                                      | 14                                      | 93.33                                        |
| Select | 56789    | Lia        | Knowledge    | Compare the different processor architectures                                 | 20                                                      | 17                                      | 85.00                                        |
| Select | 56789    | Lia        | Knowledge    | Recognize the input/output mechanisms                                         | 20                                                      | 19                                      | 95.00                                        |
| Select | 56789    | Lia        | Skill        | Interface digital circuits to microprocessor systems                          | 10                                                      | 4                                       | 40.00                                        |
| Select | 56789    | Lia        | Skill        | Design and analyze the main functional units of a computer                    | 20                                                      | 19                                      | 95.00                                        |
| Total  |          |            |              |                                                                               |                                                         |                                         |                                              |

**Figure 40: DLP System, Lia DLP and achievements after grading final exam**

**Course Assessments**

Course Name:  Student Name:

course\_assess\_id  learning\_outcome\_id  outcome\_type

stud\_grade

assess\_name  assess\_grade  questions  question\_grade

|                                                                               | Final |    |    |    | Mid |    |    | Project |       | Grand Total |
|-------------------------------------------------------------------------------|-------|----|----|----|-----|----|----|---------|-------|-------------|
| lo_title                                                                      | Q1    | Q2 | Q3 | Q4 | Q1  | Q2 | Q3 | Task1   | Task2 |             |
|                                                                               | 5     | 5  | 10 | 20 | 10  | 10 | 10 | 10      | 20    |             |
| Design and analyze the main functional units of a computer                    |       |    |    |    |     |    |    |         |       | 19          |
| Interface digital circuits to microprocessor systems                          |       |    |    |    |     |    |    | 4       |       | 4           |
| Compare the different processor architectures                                 |       |    | 8  |    |     |    | 9  |         |       | 17          |
| Recognize the input/output mechanisms                                         |       |    |    | 19 |     |    |    |         |       | 19          |
| Recognize the detailed operation of a simple microprocessor                   |       | 5  |    |    |     | 9  |    |         |       | 14          |
| Analyze the organisation of a computer system in terms of its main components | 4     |    |    |    | 6   |    |    |         |       | 10          |
| Grand Total                                                                   | 4     | 5  | 8  | 19 | 6   | 9  | 9  | 4       | 19    | 83          |

**Figure 41: DLP System, Lia Matrix Grades (LO, Exam, Grade) from the System**

### 6.3.2.2 Data Transmission Course

This course has two assessments: Final 60% and Project 40%.

**Data Transmission**

Assessment & Grading  
Settings Outcomes Questions Grades

**Grading Sheet**

Assessment: Final Grade: 60 Refresh Student List: Refresh

|      | RegNo | Stud_Name | Q1-A(7grade) | Q1-B(5grade) | Q2-A(5grade) | Q2-B(2grade) | Q2-C(7grade) | Q2-D(4grade) | Q3(9grade) | Q4-A(4grade) | Q4-B(5grade) | Q5-A(4grade) | Q5-B(8grade) | Total |
|------|-------|-----------|--------------|--------------|--------------|--------------|--------------|--------------|------------|--------------|--------------|--------------|--------------|-------|
| Edit | 65432 | Ahmad DT  | 6            | 4            | 4            | 1            | 5            | 4            | 5          | 1            | 4            | 3            | 6            |       |
| Edit | 76542 | Alaa      | 2            | 1            | 2            | 1            | 4            | 4            | 5          | 4            | 3            | 4            | 6            |       |
| Edit | 23456 | Mohammad  | 5            | 3            | 2            | 1            | 6            | 4            | 5          | 1            | 1            | 2            |              |       |

**Data Transmission**

Assessment & Grading  
Settings Outcomes Questions Grades

**Grading Sheet**

Assessment: Project Grade: 40 Refresh Student List: Refresh

Figure 42: DLP System, Grading Final and Project Exams respectively

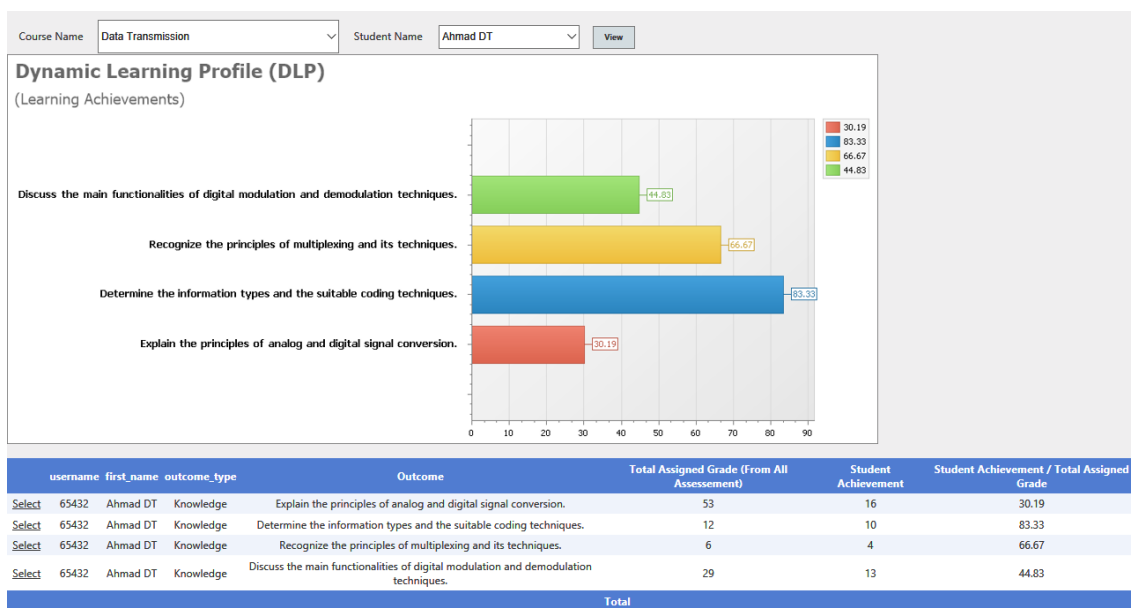
Students DLPs:

1- AhmedDT

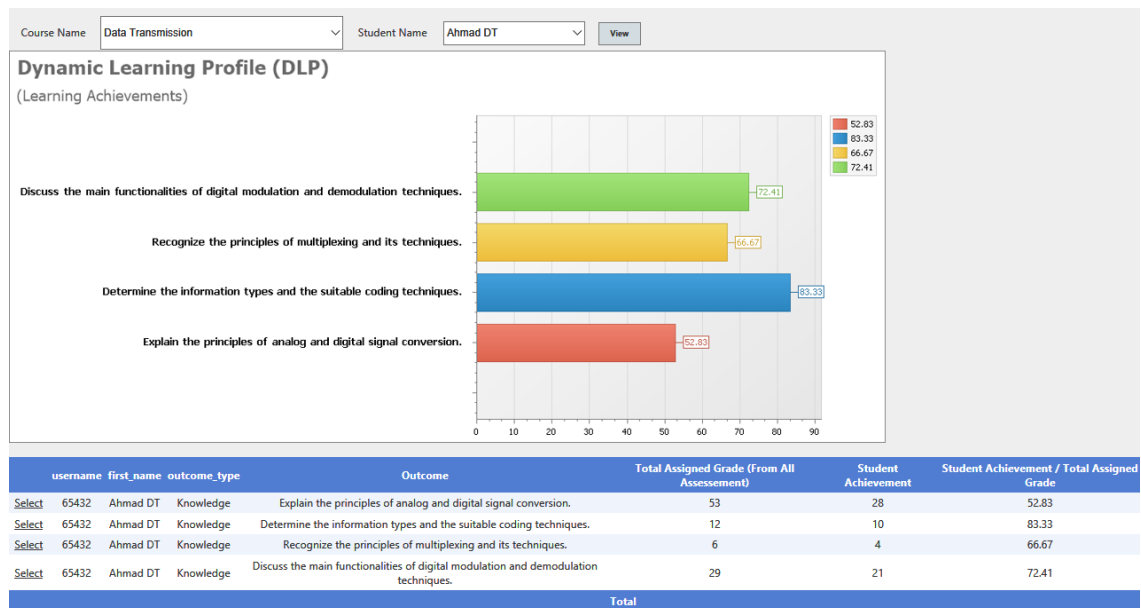
| AhmedDT                                                                                                                    | Data Transmission Course, LO-AE Matrix |               |         |          |         |          |                          |                             |
|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------|---------------|---------|----------|---------|----------|--------------------------|-----------------------------|
|                                                                                                                            | Assessments                            | Question/Task | LO1     | LO2      | LO3     | LO4      | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                            | Final                                  | Q1            | 6       |          | 4       |          | 43%                      | 60%                         |
|                                                                                                                            |                                        | Q2            | 4       | 1        | 5       | 4        |                          |                             |
|                                                                                                                            |                                        | Q3            | 5       |          |         |          |                          |                             |
|                                                                                                                            |                                        | Q4            | 1       |          | 4       |          |                          |                             |
|                                                                                                                            |                                        | Q5            |         | 3        |         | 6        |                          |                             |
|                                                                                                                            | Project                                | T1            |         |          |         |          | 0%                       | 40%                         |
|                                                                                                                            |                                        | T2            |         |          |         |          |                          |                             |
|                                                                                                                            | Total Student Percentage (S)           |               | 16%     | 4%       | 13%     | 10%      | 43%                      | 100%                        |
| Total LO Percentage (T)                                                                                                    |                                        | 53%           | 6%      | 29%      | 12%     |          |                          |                             |
| Student LO Achievement (S/T)%                                                                                              |                                        | 30%           | 67%     | 45%      | 83%     |          |                          |                             |
|                                                                                                                            | Student LO Achievement Status          |               | Desired | Achieved | Desired | Achieved |                          |                             |
| Achieved = if (S/T) >= 60%       Desired = if (S/T) < 60%       Unachieved = if (S/T) < 60% AND all assessments are graded |                                        |               |         |          |         |          |                          |                             |

| AhmedDT                                                                                                                    | Data Transmission Course, LO-AE Matrix |               |            |          |          |          |                          |                             |
|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------|---------------|------------|----------|----------|----------|--------------------------|-----------------------------|
|                                                                                                                            | Assessments                            | Question/Task | LO1        | LO2      | LO3      | LO4      | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                            | Final                                  | Q1            | 6          |          | 4        |          | 43%                      | 60%                         |
|                                                                                                                            |                                        | Q2            | 4          | 1        | 5        | 4        |                          |                             |
|                                                                                                                            |                                        | Q3            | 5          |          |          |          |                          |                             |
|                                                                                                                            |                                        | Q4            | 1          |          | 4        |          |                          |                             |
|                                                                                                                            |                                        | Q5            |            | 3        |          | 6        |                          |                             |
|                                                                                                                            | Project                                | T1            | 12         |          |          |          | 20%                      | 40%                         |
|                                                                                                                            |                                        | T2            |            |          | 8        |          |                          |                             |
|                                                                                                                            | Total Student Percentage (S)           |               | 28%        | 4%       | 21%      | 10%      | 63%                      | 100%                        |
| Total LO Percentage (T)                                                                                                    |                                        | 53%           | 6%         | 29%      | 12%      |          |                          |                             |
| Student LO Achievement (S/T)%                                                                                              |                                        | 53%           | 67%        | 72%      | 83%      |          |                          |                             |
|                                                                                                                            | Student LO Achievement Status          |               | Unachieved | Achieved | Achieved | Achieved |                          |                             |
| Achieved = if (S/T) >= 60%       Desired = if (S/T) < 60%       Unachieved = if (S/T) < 60% AND all assessments are graded |                                        |               |            |          |          |          |                          |                             |

**Table 13: MS Excel, AhmedDT Achievements after each exam grading**



**Figure 43: DLP System, AhmedDT DLP and achievements after grading final exam**



**Figure 44: DLP System, AhmedDT DLP and achievements after grading project**

Course Assessments

Course Name

Data Transmission

Student Name

Ahmad DT

View

course\_assess\_id

learning\_outcome\_id

outcome\_type

stud\_grade

assess\_name

assess\_grade

questions

question\_grade

| lo_title                                                                            | Final |      |      |      |      |      |    |      |      |      | Project |    | Grand Total |    |
|-------------------------------------------------------------------------------------|-------|------|------|------|------|------|----|------|------|------|---------|----|-------------|----|
|                                                                                     | 60    |      |      |      |      |      |    |      |      |      | 40      |    |             |    |
|                                                                                     | Q1-A  | Q1-B | Q2-A | Q2-B | Q2-C | Q2-D | Q3 | Q4-A | Q4-B | Q5-A | Q5-B    | T1 |             | T2 |
| Determine the information types and the suitable coding techniques.                 | 7     | 5    | 5    | 2    | 7    | 4    | 9  | 4    | 5    | 4    | 8       | 28 | 12          | 10 |
| Discuss the main functionalities of digital modulation and demodulation techniques. |       |      | 4    |      |      |      | 4  |      |      | 4    |         |    | 8           | 21 |
| Explain the principles of analog and digital signal conversion.                     | 6     |      |      | 4    |      |      |    | 5    | 1    |      |         | 12 |             | 28 |
| Recognize the principles of multiplexing and its techniques.                        |       |      |      |      | 1    |      |    |      |      | 3    |         |    |             | 4  |
| Grand Total                                                                         | 6     | 4    | 4    | 1    | 5    | 4    | 5  | 1    | 4    | 3    | 6       | 12 | 8           | 63 |

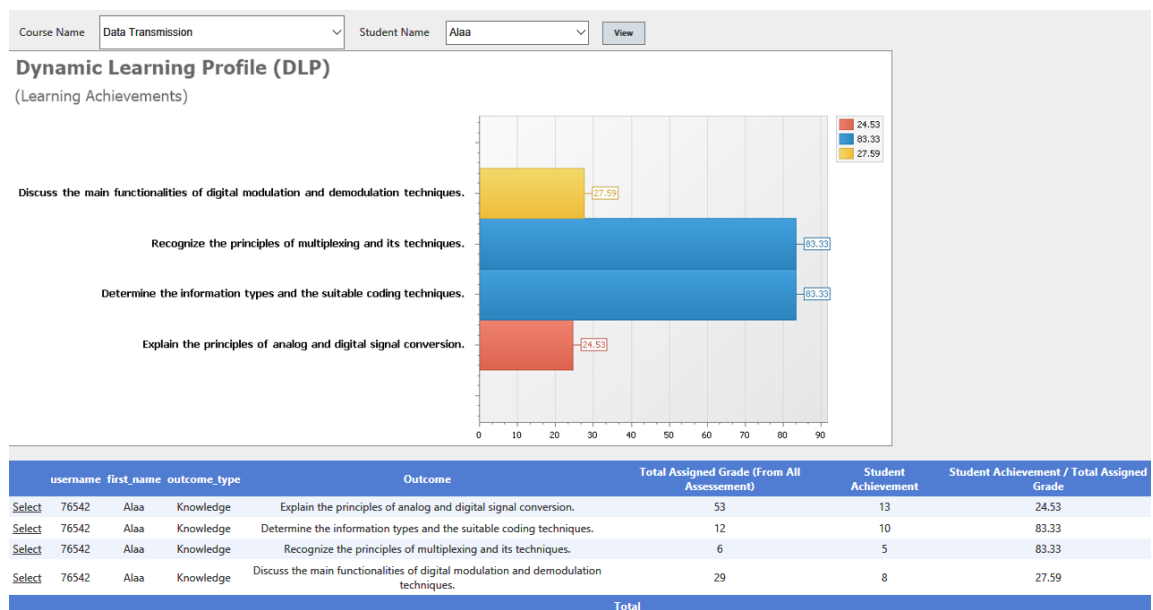
**Figure 45: DLP System, AhmedDT Matrix Grades (LO, Exam, Grade)**

2- Alaa

| Alaa                       | Data Transmission Course, LO-AE Matrix |                          |         |                                                            |         |          |                          |                             |
|----------------------------|----------------------------------------|--------------------------|---------|------------------------------------------------------------|---------|----------|--------------------------|-----------------------------|
|                            | Assessments                            | Question/Task            | LO1     | LO2                                                        | LO3     | LO4      | Total Student Percentage | Total Assessment Percentage |
|                            | Final                                  | Q1                       | 2       |                                                            | 1       |          | 36%                      | 60%                         |
|                            |                                        | Q2                       | 2       | 1                                                          | 4       | 4        |                          |                             |
|                            |                                        | Q3                       | 5       |                                                            |         |          |                          |                             |
|                            |                                        | Q4                       | 4       |                                                            | 3       |          |                          |                             |
|                            |                                        | Q5                       |         | 4                                                          |         | 6        |                          |                             |
|                            | Project                                | T1                       |         |                                                            |         |          | 0%                       | 40%                         |
|                            |                                        | T2                       |         |                                                            |         |          |                          |                             |
|                            | Total Student Percentage (S)           |                          | 13%     | 5%                                                         | 8%      | 10%      | 36%                      | 100%                        |
|                            | Total LO Percentage (T)                |                          | 53%     | 6%                                                         | 29%     | 12%      |                          |                             |
|                            | Student LO Achievement (S/T)%          |                          | 25%     | 83%                                                        | 28%     | 83%      |                          |                             |
|                            | Student LO Achievement Status          |                          | Desired | Achieved                                                   | Desired | Achieved |                          |                             |
| Achieved = if (S/T) >= 60% |                                        | Desired = if (S/T) < 60% |         | Unachieved = if (S/T) < 60% AND all assessments are graded |         |          |                          |                             |

| Alaa                       | Data Transmission Course, LO-AE Matrix |                          |            |                                                            |            |          |                          |                             |
|----------------------------|----------------------------------------|--------------------------|------------|------------------------------------------------------------|------------|----------|--------------------------|-----------------------------|
|                            | Assessments                            | Question/Task            | LO1        | LO2                                                        | LO3        | LO4      | Total Student Percentage | Total Assessment Percentage |
|                            | Final                                  | Q1                       | 2          |                                                            | 1          |          | 36%                      | 60%                         |
|                            |                                        | Q2                       | 2          | 1                                                          | 4          | 4        |                          |                             |
|                            |                                        | Q3                       | 5          |                                                            |            |          |                          |                             |
|                            |                                        | Q4                       | 4          |                                                            | 3          |          |                          |                             |
|                            |                                        | Q5                       |            | 4                                                          |            | 6        |                          |                             |
|                            | Project                                | T1                       | 8          |                                                            |            |          | 16%                      | 40%                         |
|                            |                                        | T2                       |            |                                                            | 8          |          |                          |                             |
|                            | Total Student Percentage (S)           |                          | 21%        | 5%                                                         | 16%        | 10%      | 52%                      | 100%                        |
|                            | Total LO Percentage (T)                |                          | 53%        | 6%                                                         | 29%        | 12%      |                          |                             |
|                            | Student LO Achievement (S/T)%          |                          | 40%        | 83%                                                        | 55%        | 83%      |                          |                             |
|                            | Student LO Achievement Status          |                          | Unachieved | Achieved                                                   | Unachieved | Achieved |                          |                             |
| Achieved = if (S/T) >= 60% |                                        | Desired = if (S/T) < 60% |            | Unachieved = if (S/T) < 60% AND all assessments are graded |            |          |                          |                             |

**Table 14: MS Excel, Alaa Achievements after each exam grading**



**Figure 46: DLP System, Alaa DLP and achievements after grading Final exam**

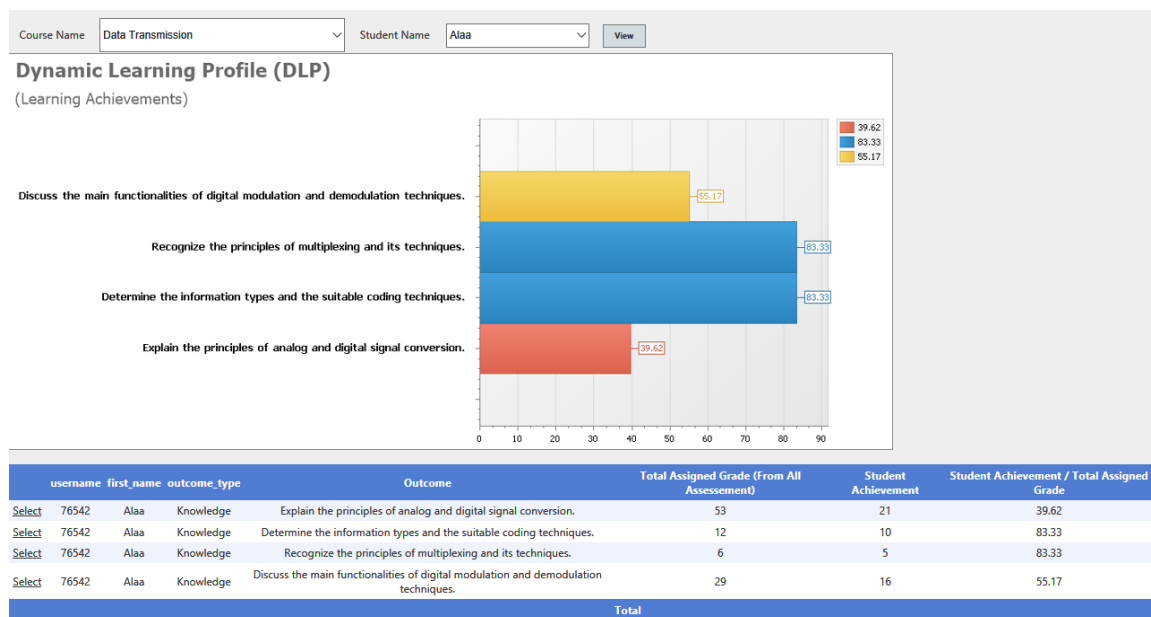


Figure 47: DLP System, Alaa DLP and achievements after grading project

Course Assessments

Course Name

Data Transmission

Student Name

Alaa

View

course\_assess\_id

learning\_outcome\_id

outcome\_type

stud\_grade

assess\_name

assess\_grade

questions

question\_grade

| lo_title                                                                            | Final |      |      |      |      |      |    |      |      |      | Project |    | Grand Total |    |
|-------------------------------------------------------------------------------------|-------|------|------|------|------|------|----|------|------|------|---------|----|-------------|----|
|                                                                                     | Q1-A  | Q1-B | Q2-A | Q2-B | Q2-C | Q2-D | Q3 | Q4-A | Q4-B | Q5-A | Q5-B    | T1 |             | T2 |
| Determine the information types and the suitable coding techniques.                 | 7     | 5    | 5    | 2    | 7    | 4    | 9  | 4    | 5    | 4    | 8       | 28 | 12          | 10 |
| Discuss the main functionalities of digital modulation and demodulation techniques. |       | 1    |      |      | 4    |      |    |      | 3    |      | 6       |    | 8           | 16 |
| Explain the principles of analog and digital signal conversion.                     | 2     |      | 2    |      |      |      | 5  | 4    |      |      |         | 8  |             | 21 |
| Recognize the principles of multiplexing and its techniques.                        |       |      |      | 1    |      |      |    |      |      | 4    |         |    |             | 5  |
| Grand Total                                                                         | 2     | 1    | 2    | 1    | 4    | 4    | 5  | 4    | 3    | 4    | 6       | 8  | 8           | 52 |

Figure 48: DLP System, Alaa Matrix Grades (LO, Exam, Grade)

### 6.3.2.3 Biostatistics Course

This course has one assessment: Final exam 100%.

Biostatistics

Assessment & Grading

Settings Outcomes Questions Grades

### Grading Sheet

Assessment: Final Grade: 100 Refresh Student List Refresh

|      | RegNo | Stud_Name | Q1-A(12grade) | Q1-B(12grade) | Q1-C(6grade) | Q2-A(18grade) | Q2-B(12grade) | Q3-A(20grade) | Q3-B(20grade) | Total |
|------|-------|-----------|---------------|---------------|--------------|---------------|---------------|---------------|---------------|-------|
| Edit | 45654 | Hanan     | 12            | 9             | 3            | 12            | 9             | 20            | 20            |       |
| Edit | 65463 | Ahmad BS  | 11            | 12            | 6            | 18            | 12            | 20            | 20            |       |
| Edit | 34543 | Madlin    | 12            | 9             | 3            | 3             | 3             | 16            | 14            |       |

Figure 49: DLP System, Grading Final Exam

## Students DLPs:

### 1- Hanan

| Hanan | Biostatistics Course, LO-AE Matrix |               |          |          |          |                          |                             |
|-------|------------------------------------|---------------|----------|----------|----------|--------------------------|-----------------------------|
|       | Assessments                        | Question/Task | LO1      | LO2      | LO3      | Total Student Percentage | Total Assessment Percentage |
|       | Final                              | Q1            | 12       | 9        | 3        | 85%                      | 100%                        |
|       |                                    | Q2            | 12       | 9        |          |                          |                             |
|       |                                    | Q3            |          | 20       | 20       |                          |                             |
|       | Total Student % (S)                |               | 24%      | 38%      | 23%      | 85%                      | 100%                        |
|       | Total LO % (T)                     |               | 30%      | 44%      | 26%      |                          |                             |
|       | Student LO Achievement (S/T)%      |               | 80%      | 86%      | 88%      |                          |                             |
|       | Student LO Achievement Status      |               | Achieved | Achieved | Achieved |                          |                             |

*Achieved* = if (S/T) >= 60% | *Desired* = if (S/T) < 60% | *Unachieved* = if (S/T) < 60% AND all assessments are graded

Table 15: MS Excel, Hanan Achievements after the exam grading

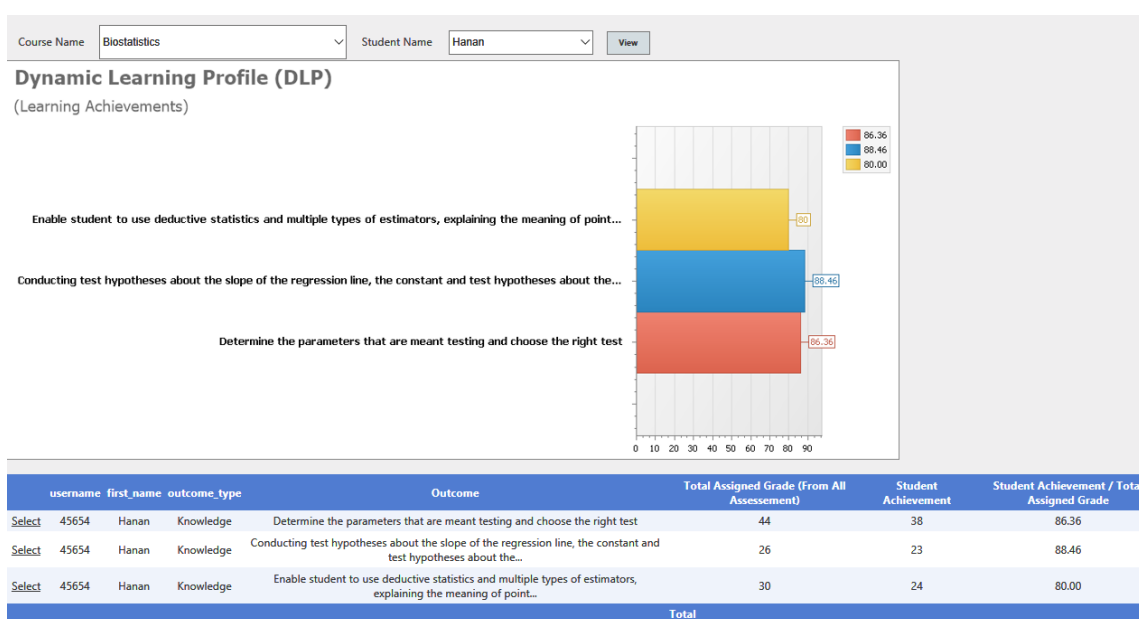


Figure 50: DLP System, Hanan DLP and achievements after grading final exam

Course Assessments

Course Name: Biostatistics Student Name: Hanan View

course\_assess\_id: learning\_outcome\_id: outcome\_type:

stud\_grade:

lo\_title:

| assess_name                                                                                                      | assess_grade | questions | question_grade |
|------------------------------------------------------------------------------------------------------------------|--------------|-----------|----------------|
| Final                                                                                                            | 100          |           |                |
| Q1-A                                                                                                             | 12           | Q1-B      | 6              |
| Q1-C                                                                                                             | 18           | Q2-A      | 12             |
| Q2-B                                                                                                             | 20           | Q3-A      | 20             |
| Q3-B                                                                                                             | 20           |           |                |
| Conducting test hypotheses about the slope of the regression line, the constant and test hypotheses about the... |              |           |                |
| Determine the parameters that are meant testing and choose the right test                                        |              |           |                |
| Enable student to use deductive statistics and multiple types of estimators, explaining the meaning of point...  |              |           |                |
| Grand Total                                                                                                      | 12           | 9         | 3              |

Figure 51: DLP System, Hanan Matrix Grades (LO, Exam, Grade)

## 2- Madlin

| Madlin                                                                                                             | Biostatistics Course, LO-AE Matrix |               |            |          |          |                          |                             |
|--------------------------------------------------------------------------------------------------------------------|------------------------------------|---------------|------------|----------|----------|--------------------------|-----------------------------|
|                                                                                                                    | Assessments                        | Question/Task | LO1        | LO2      | LO3      | Total Student Percentage | Total Assessment Percentage |
|                                                                                                                    | Final                              | Q1            | 12         | 9        | 3        | 60%                      | 100%                        |
|                                                                                                                    |                                    | Q2            | 3          | 3        |          |                          |                             |
|                                                                                                                    |                                    | Q3            |            | 16       | 14       |                          |                             |
|                                                                                                                    | Total Student % (S)                |               | 15%        | 28%      | 17%      | 60%                      | 100%                        |
|                                                                                                                    | Total LO % (T)                     |               | 30%        | 44%      | 26%      |                          |                             |
|                                                                                                                    | Student LO Achievment (S/T)%       |               | 50%        | 64%      | 65%      |                          |                             |
|                                                                                                                    | Student LO Achievment Status       |               | Unachieved | Achieved | Achieved |                          |                             |
| Achieved = if (S/T) >= 60%   Desired = if (S/T) < 60%   Unachieved = if (S/T) < 60% AND all assessments are graded |                                    |               |            |          |          |                          |                             |

Table 16: MS Excel, Madlin Achievements after the exam grading

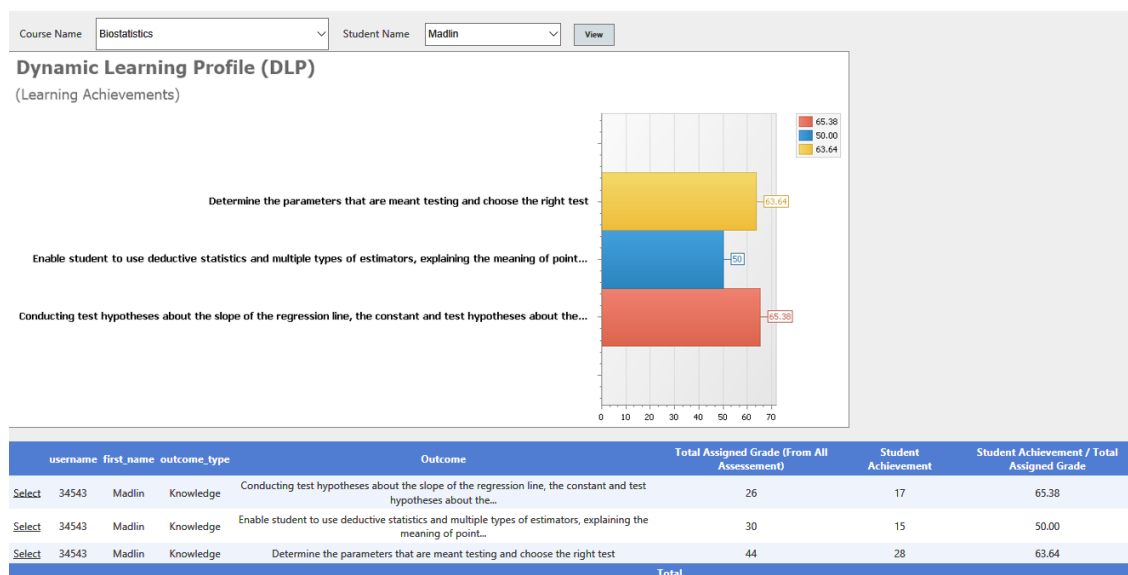


Figure 52: DLP System, Madlin DLP and achievements after grading final exam

|                                                                                                                                                                                                                                                                                                                                                                                    |               |                     |        |                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|--------|----------------|
| Course Name                                                                                                                                                                                                                                                                                                                                                                        | Biostatistics | Student Name        | Madlin | View           |
| course_asses_id                                                                                                                                                                                                                                                                                                                                                                    |               | learning_outcome_id |        | outcome_type   |
| stud_grade                                                                                                                                                                                                                                                                                                                                                                         |               | asses_name          |        | asses_grade    |
| lo_title                                                                                                                                                                                                                                                                                                                                                                           |               | questions           |        | question_grade |
| <div> <input type="checkbox"/> Final           <input type="checkbox"/> 100           <input type="checkbox"/> Q1-A           <input type="checkbox"/> Q1-B           <input type="checkbox"/> Q1-C           <input type="checkbox"/> Q2-A           <input type="checkbox"/> Q2-B           <input type="checkbox"/> Q3-A           <input type="checkbox"/> Q3-B         </div> |               |                     |        |                |
| Conducting test hypotheses about the slope of the regression line, the constant and test hypotheses about the...                                                                                                                                                                                                                                                                   | 12            | 12                  | 6      | 18             |
| Determine the parameters that are meant testing and choose the right test                                                                                                                                                                                                                                                                                                          |               | 9                   |        | 3              |
| Enable student to use deductive statistics and multiple types of estimators, explaining the meaning of point...                                                                                                                                                                                                                                                                    | 12            |                     |        | 3              |
| Grand Total                                                                                                                                                                                                                                                                                                                                                                        | 12            | 9                   | 3      | 3              |

Figure 53: DLP System, Madlin Matrix Grades (LO, Exam, Grade)

## 6.4 LOs Achievements Results

Table 17 shown the LOs achievement percentage for each student in the three courses, and the average percentage for each LO in each course.

| Computer Architecture and Organization Course LO Achievements for all Students |                      |                      |                      |                      |                      |                      |
|--------------------------------------------------------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Student                                                                        | LO1<br>Achievement % | LO2<br>Achievement % | LO3<br>Achievement % | LO4<br>Achievement % | LO5<br>Achievement % | LO6<br>Achievement % |
| <i>Ahmed</i>                                                                   | 53%                  | 80%                  | 70%                  | 95%                  | 40%                  | 85%                  |
| <i>Lia</i>                                                                     | 67%                  | 93%                  | 85%                  | 95%                  | 40%                  | 95%                  |
| <i>Leen</i>                                                                    | 67%                  | 93%                  | 95%                  | 95%                  | 70%                  | 95%                  |
| <b>Average LO<br/>Achievement</b>                                              | <b>62%</b>           | <b>89%</b>           | <b>83%</b>           | <b>95%</b>           | <b>50%</b>           | <b>92%</b>           |

| Data Transmission Course LO Achievements for all Students |                      |                      |                      |                      |
|-----------------------------------------------------------|----------------------|----------------------|----------------------|----------------------|
| Student                                                   | LO1<br>Achievement % | LO2<br>Achievement % | LO3<br>Achievement % | LO4<br>Achievement % |
| <i>AhmedDT</i>                                            | 53%                  | 67%                  | 72%                  | 83%                  |
| <i>Alaa</i>                                               | 40%                  | 83%                  | 55%                  | 83%                  |
| <i>Mohammad</i>                                           | 47%                  | 50%                  | 62%                  | 67%                  |
| <b>Average LO<br/>Achievement</b>                         | <b>47%</b>           | <b>67%</b>           | <b>63%</b>           | <b>78%</b>           |

| Biostatistics Course LO Achievements for all Students |                      |                      |                      |
|-------------------------------------------------------|----------------------|----------------------|----------------------|
| Student                                               | LO1<br>Achievement % | LO2<br>Achievement % | LO3<br>Achievement % |
| <i>Hanan</i>                                          | 80%                  | 86%                  | 88%                  |
| <i>AhmadB</i>                                         | 97%                  | 100%                 | 100%                 |
| <i>Madllin</i>                                        | 50%                  | 64%                  | 65%                  |
| <b>Average LO<br/>Achievement</b>                     | <b>76%</b>           | <b>83%</b>           | <b>85%</b>           |

**Table 17: LOs Achievements Results in all Courses**

## 6.5 Results and Analysis

After Conducting the experiment to proof the DLP Model that designed and implemented in this research, we grouped the results into four categories as follows:

### A. Learning Outcomes Achievement Evaluation (LO-AE) Model

The experiment shown that a model for evaluating LOs achievements is implemented and tested on three courses. And testing the LO-AE model has performed using the LO-AE Matrix through two phases:

1. **Assessment Design Phase:** in this phase, we designed the LO-AE Matrix for the courses by selecting the course LOs, Assigning the assessment weights with LOs, and finally designing each assessment, by mapping each question with a specific LO with score. And the results of this phase: three LO-AE matrices were implemented, and each LO in each course has a specific total percentage the student should achieve as shown in Table 10. Moreover, instructors will be able to design the LO-AE Matrix through the mechanism that provided in the DLP proof of concept system and shown in Figures 28, 29 and 30.
2. **DLP Creation Phase:** in this phase, the grading process for the three courses has started and repeated after each assessment in the course as shown in Figure 33 for the CAO Course. Furthermore, after each grading process the student LOs achievements have increased and each student has an achievement percentage for each LO. For example, the LO achievement for the student Ahmed in the COA course for LO1, LO2 and LO3 have increased from 33%, 53% and 35% to 53%, 80% and 70% after grading the final exam as shown in Ahmed's LO-AE Matrix in Table 11. And the results of this phase: each student has an achieved percentage on each LO in the three courses as shown in Table 17.

#### **B. A Dynamic Learning Profile based on Learning Outcomes (DLP Model)**

The experiment shown that a complete Dynamic Learning Profile based on Learning Outcomes model has implemented and tested on three courses. The model includes the LO-AE model for evaluating the LO Achievements as mentioned above in section A. And the Learning Outcomes Achievement Profile (LO-AP) for storing, updating and sharing the LO-AE Matrix results as shown in Figures 34, 35, 36 and 37. And the last one is the LO-AT module for tracking and updating the LO Achievements during the course states that mentioned before in section 3.4.3. thus,

in the DLP initial state the LO-AT was responsible for adding all the LOs into the student's LO-AP as shown in Figure 31. And during the semester, the LO-AT was responsible for updating the student's LO-AP after each grading process as shown in Table 11 and Figures 34, 35 and 36.

### **C. DLP Model to Enhance the Course Curriculum and Pedagogy**

The results in Table 17, shown the average students' achievement for each LO in the courses which is useful for Instructors and decision makers. For example, the Data Transmission Course in Table 17 shown that LO1 has the lowest achievement average for all students with 47%. This low average provides the instructor with the learning outcomes that most of the students did not achieve. And based on that, the instructor will be able to look and analyze the reasons behind this low average to enhance the LO achievement average for students during the course or in the next semesters.

## **7. CONCLUSIONS**

### **7.1 Summary and Contributions**

In this research, a Dynamic Learning Profile (DLP) model has designed and implemented. The DLP is a complete model consists of three modules for evaluating, tracking and storing the learners' LOs achievements. Also, the DLP model provided a way to identify the learning needs for learners based on the LOs achievements during the learning process. Therefore, learners will have a clear expectation of their learning progress. And they will have the chance to improve their performance based on their achievements in the LOs.

Moreover, the DLP will provide learners with their achievements as what they know and able to do. Therefore they can share these achievements as personal resumes with the employers and with the other educational institutions.

Furthermore, with the DLP model, learners and instructors will be able to deal with the LOs in a tangible way. So that, they can visualize the important relation between the LOs and the learning material and the LOs with the assessments in the course.

In terms of enhancing the course, the DLP will provide the instructors and the decision makers with detailed information on the average LOs achievements for learners. Therefore, they will be able to conduct statistical analysis to identify the potential problems, improve the LOs achievement and enhance the course.

### **7.2 Future Work**

Three potential improvements on the DLP model can be developed in the future. The first one is to design and implement a learning object recommender module (LORM) can be connected with the LO-AP. The LORM will responsible for sensing the learner

LOs achievement percentage to provide him with relevant learning objects to enhance his achievements. The second one is to design and implement a learning outcomes analyzer module (LO-AM), to analyze the history of the LOs achievements for learners. The LO-AM will provide instructors and decision makers with analytical results and recommendations to enhance the course and the learners' LOs achievements. The last improvement is to provide a descriptive technique (Rubrics) to describe the LOs achievements for learners.

## REFERENCES

- [1] EUROPEAN COMMISSION Education and Culture, "The European Qualifications Framework for lifelong learning (EQF)," European Communities, Belgium, 2008.
- [2] M. Tam, "Outcomes-based approach to quality assessment and curriculum improvement in higher education," *Quality Assurance in Education*, vol. 22, no. 2, pp. 158-168, 2014.
- [3] S. Malan, "The 'new paradigm' of outcomes-based education in perspective," *Journal of Family Ecology and Consumer Sciences/Tydskrifvir Gesinsekologie en Verbruikerswetenskappe*, vol. 28, pp. 22-28, 2000.
- [4] M. Gaeta, S. Miranda, F. Orciuoli, S. Paolozzi and A. Poce, "An Approach To Personalized e-Learning," *Journal of Systemics, Cybernetics and Informatics*, vol. 11 (1), pp. 15-21, 2013.
- [5] L. A. M. Zaina and G. Bressan , "Classification of Learning Profile Based on Categories of Student Preferences," in *38th ASEE/IEEE Frontiers in Education*, saratoga springs, NY, 2008.
- [6] Y. Kritikou, P. Demestichas, E. Adamopoulou, K. Demestichas, M. Theologou and M. Paradia, "User Profile Modeling in the context of web-based learning management systems," *Journal of Network and Computer Applications*, vol. 31, no. 4, pp. 603-627, 2008.
- [7] N. Capuano, M. Gaeta, A. Micarelli and E. Sangineto, "An Intelligent Web Teacher System for Learning Personalization and Semantic Web Compatibility," in *11th*

- International PEG Conference “Powerful ICT for Teaching and Learning”*, St. Petersburg, Russia, 2003.
- [8] N. Capuano, S. Miranda and F. Orciuoli , "IWT: A Semantic Web-based Educational System," in *The XIth International Conference of the Italian Association for Artificial Intelligence*, Reggio Emilia, Italy, 2009.
- [9] L. A. Zaina, J. . F. Rodrigues, M. . A. C. d. A. Cardieri and G. Bressan , "Adaptive learning in the educational e-LORS system: an approach based on preference categories," *International Journal of Learning Technology*, vol. 6 (4), pp. 341-361, 2011.
- [10] R. Felder and L. Silverman, "Learning and teaching styles in engineering education," *Journal of Engineering Education*, vol. 78 (7), p. 674–681, 1988.
- [11] J. Najjar, M. Derntl, T. Klobucar, B. Simon, M. Totschnig, S. Grant and J. Pawlowski, "A Data Model for Describing and Exchanging Personal Achieved Learning Outcomes (PALO)," *International Journal of IT Standards and Standardization Research (IJITSR)*, vol. 8, no. 2, pp. 87-104, 2010.
- [12] J. Najjar, B. Simon and T. Klobucar, "ISURE: Report on implementation and validation of a standardized model for learning needs analysis and the provision of learning opportunities," iCOPER project, co-funded by the European Community eContentplus Programme, European Community, 2011.
- [13] IEEE Computer Society, "IEEE LTSC Reusable Competency Definitions (RCD)," IEEE, New York, 2007.
- [14] European Centre for the Development of Vocational Training (Cedefop), "The shift to learning outcomes Conceptual, political and practical developments in Europe," Office for Official Publications of the European Communities, Luxembourg, 2008.

- [15] P. Ramsden, *Learning to Teach in Higher Education*, New York: Routledge Falmer, 2003.
- [16] D. Kennedy, "Linking Learning Outcomes and Assessment of Learning of Student Science Teachers," *Science Education International, International Council of Associations for Science Education*, vol. 19 (4), pp. 387-397, 2008.
- [17] R. Falcão, "ALOA: a model for Aligning Learning Outcomes and Assessment," in *45th EUCEN CONFERENCE* , Geneva, Switzerland, 2013.
- [18] L. Anderson and D. Krathwohl , *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, New York: Longman, 2001.
- [19] D. Boud and N. Falchikov, "Aligning assessment with long-term learning," *Assessment & Evaluation in Higher Education*, vol. 31 (4), p. 399–413, 2006.
- [20] J. Biggs and C. Tang, *Teaching for Quality Learning at University: What the Student Does*, Poland: Open University Press and McGraw-Hill Education, 2007.
- [21] I. Z. Abidin, A. Anuar and N. H. Shuaib, "ASSESSING THE ATTAINMENT OF COURSE OUTCOMES (CO) FOR AN ENGINEERING COURSE," in *2nd International Conference of Teaching and Learning* , Malaysia, 2009.
- [22] I. Sommerville , *Software Engineering (9th Edition)*, New York: Addison-Wesley, 2011.

بناء الملف التعليمي اعتماداً على مخرجات التعلم التي تم تحقيقها (DLP)

إعداد: بهاء (محمد غالب) خضر ثابت

إشراف: د. بديع سرطاوي

الملخص

أصبح إضفاء الطابع الشخصي على التعلم (Learning Personalization) من الإتجاهات الصاعدة في التعليم لتلبية احتياجات المتعلمين في بيئات التعلم عبر الإنترنت. وهناك العديد من الأبحاث والدراسات السابقة التي أجريت في تخصيص بيئات التعلم بهدف تعزيز تجربة المتعلمين اعتماداً على أنماط تعلمهم والحالة المعرفية التي أكتسبوها. وقد حاولت هذه الدراسات بناء ملف المتعلم الشخصي وتحديد احتياجات المتعلم بناءً على المجالات التعليمية باستخدام عدة منهجيات وأدوات مثل: تقنية فهم دلالات الويب (Semantic Web)، والإستبانات (Questionnaires)، والتنبؤ (Prediction).

وبالمقابل، تقدم هذه الدراسة نموذج بناء الملف التعليمي اعتماداً على مخرجات التعلم التي تم تحقيقها (DLP). ويهدف النموذج الى تحديد احتياجات المتعلم وبناء ملفه التعليمي بطريقة ديناميكية (Dynamic Learning Profile) وفقاً لما حققه من إنجازات في مخرجات التعلم (Achieved Learning Outcomes) أثناء فترة تعلمه. وقد تم تصميم وتطوير نموذج DLP ليتكون من ثلاثة أجزاء، وهي أولاً: تقييم إنجازات المتعلم في مخرجات التعلم (LO-AE)، ويهدف الى تقييم أداء المتعلم اعتماداً على مخرجات التعلم باستخدام أدوات التقويم الرسمية (Formal Assessments). ثانياً: تتبع إنجازات مخرجات التعلم (LO-AT)، ويهدف الى تتبع مسيرة المتعلم أثناء تعلمه لرصد الإنجازات الجديدة وتحديث ملف تعلمه. ثالثاً: ملف إنجازات مخرجات التعلم (LO-AP)، ويهدف الى حفظ إنجازات المتعلم في ملف شخصي للإنجازات التعليمية على مستوى مخرجات التعلم.

ويوفر نموذج بناء الملف التعليمي إعتماًداً على مخرجات التعلم التي تم تحقيقها (DLP) وسيلة ملموسة وحقيقية للعلاقة بين مخرجات التعلم والتقويم وأداء المتعلم. حيث يمكن المتعلمين من معرفة آدائهم على شكل إنجازات مرتبطة بمخرجات تعلم أكثر من كونه أرقام أو معدلات مجردة. ويوفر كذلك الفرصة للمتعلمين من معرفة احتياجاتهم التعليمية بشكل دقيق يمكنهم من البحث عن مصادر تعليمية لتعزيز آدائهم. وبذلك سيكون لدى المتعلمين توقعات واضحة لما يعرفونه وقادرين على القيام به على شكل ملفات إنجاز يمكن مشاركتها مع المؤسسات التعليمية وأصحاب الأعمال والمشغلين.

وبالمقابل، يوفر نموذج DLP أيضاً للمعلمين وأصحاب القرار فرصة تحليل ودراسة نتائج المتعلمين وآدائهم إعتماًداً على مخرجات التعلم وإنجازات المتعلمين بها، مما يعطي الفرصة لتحسين المساقات ومخرجات التعلم لدى الطلبة.