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An Enhanced Adaptive Learning System based on Microservice Architecture

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Abstract

This study aims to enhance Adaptive Learning Systems (ALS) in Petroleum Sector in Egypt by using the Microservice Architecture and measure the impact of enhancing ALS by participating ALS users through a statistical study and questionnaire directed to them if they accept to apply the Cloud Computing Service "Microservices" to enhance the ALS performance, quality and cost value or not. The study also aims to confirm that there is a statistically significant relationship between ALS and Cloud Computing Service "Microservices" and prove the impact of enhancing the ALS by using Microservices in the cloud in Adaptive Learning in the Egyptian Petroleum Sector. After developing and strengthening the ALS using the cloud computing with the benefits of using Function as a Services "FaaS", the functions are start rapidly in order to allow handling of individual requests by using the Microservice Architecture. This study includes a description of the statistic field study approach (The study's community and its sample. As well as used tools, methodologies, and their validity and reliability. It also includes used procedures for tools codification and their application. Finally, statistical processes that were relied upon in study analysis).

Keywords

Adaptive Learning System, Microservice Architecture, Functions as a Service, Adaptive Learning Environment, Platform as a Service, Information Systems Development.

1. Introduction

Personalized learning experiences resulting from a data-driven approach to curriculum design. This method builds the term adaptive learning refers to a method of online instruction that involves providing on customized learning paths derived from algorithms, course analytics, assessment data, and feedback from students and can be used both to provide remediation and to help learners achieve mastery of content. In contrast, a standard course is typically more linear and does not include customized learning paths for students [1]. The enhancements and improvements in Adaptive Learning Systems (ALS) need to be optimized on its utilization based on using the cloud computing architecture and its Microservices technology by functions as a services platform. Adaptive learning is an important aspect in many fields but it needs a new technology like Microservices to enhance the performance and quality of its processing to face the modern progressive development [2]. This study aims to enhance ALS performance by cloud based adaptive learning application using Microservices to provide an efficient, effective and customized learning experience for students by dynamically adapting learning content to suit their individual abilities or preferences. They attempt to change the presentation of material to fit each learner and to collect information about learner's goals, preferences and knowledge in order to adapt the education needs of that learner [3].

As shown by IoT and network integration in the context of edge cloud and fog computing, cloud technology is evolving towards greater spread across multi-clouds and the incorporation of diverse devices. For this architectural environment with fewer, but still virtualized machines to host application and platform services, as well as the logistics needed to manage this, lightweight virtualization solutions are often advantageous. Currently, containerization is being proposed as a cheap virtualization approach. Containers are particularly relevant for platform issues normally handled by Platform-as-a-Service (PaaS) clouds, such as application packaging and orchestration, in addition to having[4] Microservices are about functional decomposition often in a domain-driven design context. They are characterized by well-defined and explicitly published interfaces [5].

Microservices in ALS will provide better performance in updating content in a short time that learners have varied origins, motivations, and learning preferences in their own learning processes, and that learning systems that overlook these distinctions struggle to satisfy learners' requirements successfully. As a result, while developing instructional materials, it is critical to include components that represent individual learning variances. [6].

2. Related Work

According to Nataliia Morze et al., Moodle LMS is one of the ALS systems that has been popular at universities because to its adaptability and free distribution. This makes the question of whether to integrate adaptivity components in Moodle crucial, and many scholars have focused on this subject in the past 10 years. The benefits of online learning include the freedom to select when to learn, complete activities while online, break up projects into smaller ones to complete them, go back to previously learned information, and access to a variety of content forms [7] . Shuai Wang et al mentioned that Adaptive learning systems personalize instruction to students' individual learning needs and abilities. Such systems have shown positive impacts on learning. Many schools in the United States have adopted adaptive learning systems, and the rate of adoption in China is accelerating, reaching almost 2 million unique users for one product alone in the past 3 years. Given such rapid adoption in China, it is useful to examine the efficacy of adaptive learning within that country's educational system. This study aimed to compare the learning impacts of individualized adaptive learning courseware to two common instructional approaches in China: large-group and small-group classroom instruction. This paper describes the results of two efficacy studies of one of China's first adaptive learning systems, Squirrel AI Learning. One study compares classroom-based individualized adaptive learning instruction to large group instruction, and another to small-group instruction. Chinese eighth-grade students from two provinces randomly assigned to use Squirrel AI Learning showed greater gains on a mathematics test than those randomly assigned to whole-class or small-group instruction led by expert teachers. Findings provide a basis for further research into the selection, use, and impact of adaptive learning systems in Chinese education [8]. According to Victoria Mirata et al., there are distinct disparities amongst learning providers that are related to various socioeconomic settings and organisational contexts (such as the kind of institution, teaching model, and implementation phase). Practical advice on the aspects to take into account when implementing adaptive learning in higher education and learning providers' contexts is provided for institutional leaders and project implementers.. These suggestions deal with the essential infrastructure, institutional commitment, backing, and assets. [9] According to Nataliia Morze et al., Moodle LMS is one of the ALS systems that has been popular at universities because to its adaptability and free distribution. This makes the question of whether to integrate adaptivity components in Moodle crucial, and many scholars have focused on this subject in the past 10 years. The benefits of online learning include the freedom to select when to learn, complete activities while online, break up projects into smaller ones to complete them, go back to previously learned information, and access to a variety of content forms. [10].

Aron Metzig mentioned that Software Elasticity is the concept of adapting available resources to the current or expected workload. This concept fits modern and stateless Microservice architectures, which are scalable by design. Their scalability is closely related to Software Resilience and places new demands on cloud architectures. In cloud computing, Elasticity describes the optimal adaptive usage of available resources. Therefore, modern orchestrators claim to provide the difficult task of resource providing and withdrawing on demand. Besides Elasticity, Resilience is essential for every cloud computing scenario. Furthermore, modern applications running in cloud scenarios follow a decentralized Microservice paradigm by splitting business logic within smaller development teams and relying on more powerful middleware. [11]. According to Antonio De Iasio & Eugenio Zimeo, continuous software engineering and microservices architecture are two growingly widely used techniques for creating and maintaining software products. A complicated application may benefit from high availability at runtime and agility during development by isolating failures and versioning in individual Microservice. The independence of the execution environments hosting Microservices is the key to this success. [12]. Isak Shabani et al mentioned that Microservices are about functional decomposition enables for instance agility, flexibility and scalability . In contrast to conventional methods of system construction, where the entire system is focused in a single, indivisible unit, distributed systems provide a change. Monolithic systems, which are the predecessors of microservices, are unable to meet the needs of today's large-scale, intricate applications. In contrast to conventional methods of system construction, where the entire system is focused in a single, indivisible unit, distributed systems provide a change. Monolithic systems, which are the predecessors of microservices, are unable to meet the needs of today's large-scale, intricate applications. In this study, we use three alternative architectural patterns to break down a monolithic programme into smaller, more manageable pieces called microservices. We then compare the two architectural types using in-depth metrics produced by the Apache JMeter tool [13].

3. Proposed Adaptive Learning System

The proposed Adaptive Learning System is as per the following procedures:

3.1. System Requirements

3.1.1. Req1: Microservices shall provide ALS users with better performance to face the modern progressive development of informational technologies in ALS.

3.1.2. Req2: Microservices shall provide ALS users with high Quality to face the modern progressive development of informational technologies in ALS.

3.1.3. Req3: Microservices shall provide ALS users with lowering cost of ALS

3.2. Proposed System Architecture

The researcher used the Cloud Services "Microservices" as a tool in the Adaptive Leaning System that will meet the features and requirements of the system. This new tool is a new technology which used to enhance the performance, quality and lowering the cost of ALS to face the modern progressive technology. The system provides enhancements and improvements of Performance, Quality and Cost Reduction in ALS and will be optimized on its utilization based on using the cloud computing architecture and its Microservices technology by functions as a services platform. The survey of the previous work mentioned that Microservices new technology used to face the modern progressive development of informational technologies in ALS, which require computation of a very high order, analyzing enormous amounts of data in real time, scalability of the system to provide the processing, loading, distribution of these data [14].

The Microservice architectures are simple. It focuses on a single component at a time. The systems designed using Microservice architecture is loosely coupled as the components of a system work independent of each others. To execute the task, every service is built, selecting the most suitable tool. This architecture allows many teams and developers to work independent of each other using the following architecture. [3]. Figure 1 shows what the Microservices Architecture softened the Adaptive Learning Application boundary represented by the dotted and dashed line styles in the diagram. This is to emphasize the point that in the Microservices architecture, it is not the application boundary that matters, it's the Microservice boundary. The Microservice boundary is shown with thick rectangles. There are many such Microservices depicted in the diagram. In short, in that place, many Microservices have popped up, and all of them have clear and concrete boundaries. **[15]**

In this collaboration pattern, a composite Microservice acts as the 'controller' which orchestrates the end-to-end application process flow by invoking multiple atomic services in a sequence. Microservice invocation is done via request/reply interaction, during the process execution. Microservice orchestration helps create complex processes. To avoid programming these mechanics manually, developers can use ready-made frameworks that contain Microservice management tools. Figure 1 below illustrates the Adaptive Learning Application provided by Microservice Architecture and its orchestration, for the same ordermanagement application described above. [16].

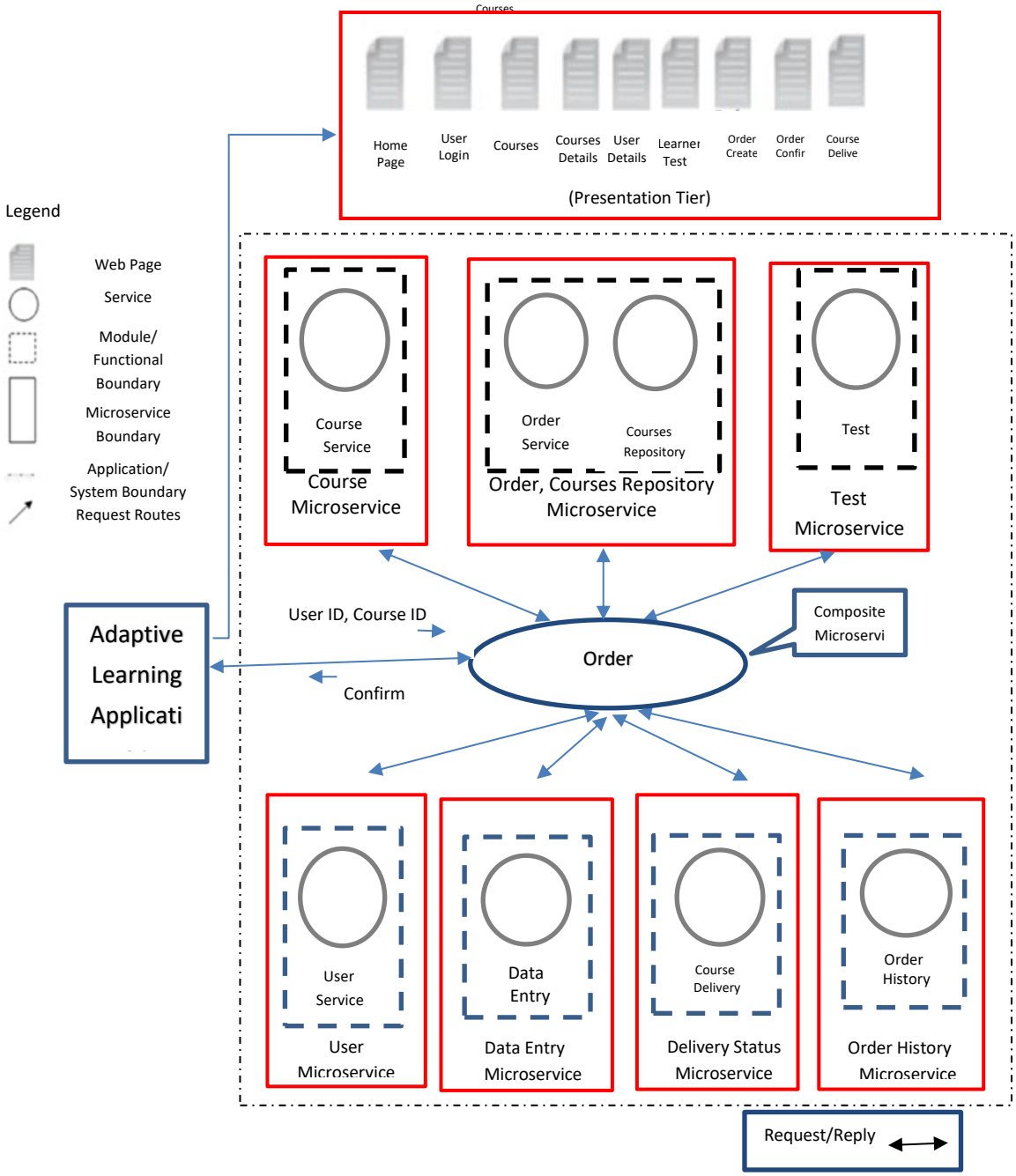

Figure 1: Adaptive Learning System based on Microservice

The proposed system is based on accepting users for applying Cloud Based ALS. The users in the ALS are the learners (engineers, technicians, IT employees, administrators) and trainers. The researcher asked users in the questionnaire and measured the

satisfaction percentage of using Microservices for enhancing Performance, Quality, and Lowering Cost of ALS. The researcher measured the acceptance of ALS and its positive change represented by the enhancements in the system performance and quality in the system by measuring time of process, flexibility, agility, scalability.

4. Requirements Validation

Requirements validation for the ALS will be as follows:

4.1. Requirements Steps

The organisational standards are the prescribed standards followed by the organisation in accordance with which the system is to be constructed, while the collected requirements are the specifications obtained from the end user. To determine if the system requirements are realistic, organisational knowledge is employed. The list of issues is discovered during the requirement validation process, as the name implies. The list of agreed-upon actions outlines the remedial measures that must be implemented to address those issues, and requirements are validated to ensure that they are comprehensive and compatible with user requirements. This phase consists of a few stages

4.2. Requirements Validation techniques

The validation techniques are as follows:

4.2.1. Reviews & Inspections technique:

Stakeholders came together during the software development process to gather and work on the project's needs. Every part of the system must be discussed using a questionnaire, and the size of the system has a big impact on the time and requirement for manpower. These labor-intensive processes also use a lot of human resources. While using this approach to work on the requirements, several stakeholder comments were taken into consideration, and different tests were run on the requirements to determine their need and usefulness in the system. The stakeholders working on the specifications should hang on to the necessary resources and the expertise to use them to sustain the requirements.

4.2.2. Testing Based Requirement Validation:

For the purposes of testing the requirements, a test case was created for each need, and these test cases aid in locating the requirements that are still lacking.

4.2.3. Viewpoint Based Requirement Validation:

Various points of view that fit the requirement's purpose can be included in one requirement.

4.2.4. Feature Oriented Requirement Validation:

A feature is a logical unit that satisfies a requirement's functional requirements. In feature-oriented validation, the feature is validated from both a structural and functional perspective. The structural perspective deals with the feature's limitations, and the functional perspective with the feature's behaviour.. **[17]**.

5. Case Study Analysis

The case study is based on the following:

5.1.Research Methodology

In order to prove the impact of cloud computing services enhancements on Adaptive Learning by using "Microservices" in the Egyptian Petroleum Sector, this study aims to involve stakeholders through a statistical study to confirm that there is a statistically significant relationship between enhancing Adaptive Learning and using Microservices.

Data analysis and investigation were conducted using a quantitative technique. The study ideas are based on the analytical results that were reached using rates, percentages, and statistical tests. The Statistical Package for Social Sciences version 25 was utilised for all of these study areas in order

5.2.Limitations

Objective limits: This study is proving the relationship and the positive impact between enhancing Adaptive Learning and Using Microservices in the Egyptian Petroleum Sector.

- Human limits: Employees in the Egyptian Petroleum Sector.
- Place limits: Arab Republic of Egypt.

5.3.Study Hypothesis

- **Hypotheses 1**: There is a statistical relation between enhancing Adaptive Learning System and using “Microservices”.
- **Hypotheses 2**: Impact of using “Microservices” for enhancing Adaptive Learning System in Egyptian Petroleum Sector by providing better performance, high quality and lower cost.

5.3.1. Examining Study Hypothesis

The researcher relied on Statistical and Standard Consulting Center, Faculty of Graduate Studies for Statistical Research.

5.3.2. Illustrating high degree of high arithmetic means, standard deviation and study sample response homogeneity degree

5.4.Study Sample

The target population for this study is more than "19085" employees in the Egyptian petroleum industry, which is the only private sector [18]. In order to best reflect the study population, the researcher selected a sample of "377" in accordance with Stephen Thompson's equation (as given in equation 1).

Equation: 1 - Stephen Thompson's equation

$$n = \frac{N\ x\ \sigma\ (1-\sigma)}{[[N-1x(d^{2} \div z^{2}\ )]+\sigma(1-\sigma)]} \quad (1)$$

Where n:no of study samples, N: population size, σ:standard deviation, d:precision, **z**:statistic of level of confidence

5.5.Sources of information and data

Th researcher designed a questionnaire as the main study tool and it was distributed to the target study sample. Because of "COVID - 19" pandemic, the form was distributed and filled online.

5.6.Sample Description

To measure the study variables, a questionnaire was designed and it is divided into two parts as follows:

First section: (Gender - Age - Academic Qualification - Employment - Using Adaptive-Learning Service - Satisfaction with services - Job Description).

Second section: (Adaptive Learning and Cloud Computing Services "Microservices) and this section consists of two subjects as follows:-

First subject: Adaptive Learning includes (15) paragraphs covering the following points:

- The Nature of Adaptive Learning.
- Knowledge of Adaptive Learning.
- Adaptive Learning Development by using Microservices.

Second subject:

The Effect of **Using "Microservices" to:**

- Enhance performance of Adaptive Learning in the Petroleum Sector.
- Enhance quality of Adaptive Learning in the Petroleum Sector.

Lowering Cost of Adaptive Learning in the Petroleum Sector.Table 1**Table 1. shows that: -**

1. The largest percentages of targeted group are males, whose percentage was 89.9%, while females were 10.1% of the total number.
2. As for the average age groups, the largest percentage goes to who are between 30 years old to 39 years old, and their percentage is 39%, followed by the age group from 40 to 49 years old and their percentage is 26%., followed by the age group from 50 to 59 years old and their percentage is 25.7%. Followed by the age group from 18 to 29 years old and their percentage is 9%., followed by the age group from 60 years old and above their percentage is 0.3 % of the total number.
3. The percentages of qualifications were university degree and their percentage was 59.7%., followed by "above average qualification" and their percentage was 14%, followed by "postgraduate studies" and their percentage was 13.3%, followed by "average qualification" and their percentage was 6.6% and "others" their percentage was 6.4% this explains that the highest percentage is for those who have a university degree.
4. As for employment, the highest percentage was for those who technician and their percentage was 44.8% out of the total number of targeted people. Followed by engineer and their percentage was 37.4%. Then by others and their percentage was 11.7%. Finally, Administrator and their percentage was 6.1%.
5. The percentage of Adaptive Learning Service users was the highest percentage of the sample, and it was 94.2%. While the non-user's percentage was 5.8% out the total number of the sample.
6. Adaptive-Learning Service satisfaction percentage is 76.1% satisfied. Followed by neutral and their percentage was 18.1 %. Followed by not satisfied and their percentage was 5.8%.
7. As for the Job Description, the highest percentage of the Administrators and their percentage was 43.2%. Then Learners and their percentage was 31.8%. Followed by others and their percentage was 17.5%, and finally Trainers and their percentage was 7.5%.

From the target group's personal data description, the repetitions and percentages were identified, and targeted group data results were summarized in Table 1.

Table 1 - Description of the study's sample

S	Statement		Number	Percentage
1	Gender	Male	339	89.9
		Female	38	10.1
Total			377	100.00
2	Age	From 18: 29 Year	34	9
		From 30: 39 Year	147	39
		From 40: 49 Year	98	26
		From 50: 59 Year	97	25.7
		From 60 years and over	1	0.3
Total			377	100.00
3	Qualification	Postgraduate studies	50	13.3
		University degree	225	59.7
		Above average qualification	53	14
		Average qualification	25	6.6
		Other	24	6.4
Total			377	100.00
4	Employment	Engineer	141	37.4
		Technician	169	44.8
		Administrator	23	6.1
		Other	44	11.7
Total			377	100.00
5	Accept Using Adaptive-Learning Service	Yes	355	94.2
		No	22	5.8
Total			377	100.00
6	Satisfaction Level	Satisfied	287	76.1
		To some extent	68	18.1
		Not satisfied	22	5.8
Total			377	100.00
7	Job Description	Trainee	120	31.8
		Trainer	28	7.5
		Administrators	163	43.2
		Other	66	17.5
Total			377	100.00

5.7.Study Tools

5.7.1. Building the study tools

After the researcher reviewed the literature and relevant previous studies, a questionnaire was designed for the targeted sample to identify their opinions on using Microservices in Adaptive Learning Systems.

5.7.2. Questionnaire description

The researcher designed a questionnaire and used primary sources for valuable information and data in the questionnaire sections, determining an appropriate scale as the researcher used five-point Likert scale, according to the following form: - (5) Strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree.

To measure the study variables, a questionnaire was designed (Closed Questionnaire) and a letter was attached with the questionnaire to explain it briefly to the targeted sample, and includes an introduction to the researcher also explains the study importance and how to fill out the questionnaire. With a statement that the information will be used for scientific research purposes only. The questionnaire consists of (37) paragraphs and it is divided into two parts as follows:

- **First section:** Consists of (7) paragraphs covering the respondents' personal data. They include the following: (gender - age - academic qualification - employment - using Adaptive-Learning service - satisfaction with services - job description).
- **Second section:** consists of (30) paragraphs. They include the main variables (Adaptive Learning and cloud computing services "Microservices") and this section consists of two subjects as follows:-

First subject: Adaptive Learning includes (15) paragraphs covering the following points:

1- The Nature of Adaptive Learning and it is divided to (5) paragraphs.
2- Knowledge of Adaptive Learning and it is divided to (5) paragraphs.
3- Adaptive Learning Development by using Cloud Computing and it is divided to (5) paragraphs.

Second subject: Using Cloud Computing Services "Microservices", includes (15) paragraphs covering the following points:

1- The Effect of Using Microservices for enhancing Quality of Adaptive Learning in the Petroleum Sector proposed in (5) paragraphs.
2- The Effect of Using Microservices for Lowering Cost of Adaptive Learning in the Petroleum Sector proposed in (5) paragraphs.

3- The Effect of Using Microservices for enhancing Performance of Adaptive Learning in the Petroleum Sector proposed in (5) paragraphs.

5.7.3. Study tools validity:

Questionnaire validity means that "the questionnaire includes all the elements which are needed for carrying out the analysis. It also means the clarity of its paragraphs and vocabulary as it should be understandable.", thus a valid questionnaire must measure what it is designed to measure.

The researcher relied on Statistical and Standard Consulting Center of the Graduate Studies for Statistical Research Faculty at Cairo University in designing. The researcher considered the questionnaire validity and the extent to which it achieves the targeted goals by presenting it to specialized arbitrators who are scientifically competent, hold academic qualification and have experience. The questionnaire validity is demonstrated in compliance of paragraphs with the research purposes where the objectives and environment of the research coincide with the objectives and environment of this study. The questionnaire was presented to Prof. Dr. Supervisor of the thesis who approved it in this study.

5.7.4. Study tools reliability:

Questionnaire reliability means that the answer should be the same in case of distributing it on the same people. To measure the questionnaire validity, the researcher used the reliability equation Cronbach's Alpha and the results are as follows.

The data in indicate that the questionnaire reliability of all paragraphs is very high as it reached (.995) for the total number of paragraphs (30). Study variables reliability ranged between (.969 - .982) which are statistically acceptable reliability in general according to "Nanli scale" which indicated that the minimum reliability is (0.70). Consequently, the questionnaire final form in the study field application was approved.

Table 2 - Reliability coefficients of the study tools and its different dimensions

S	Study subjects	Dimensions	Number of paragraphs	Reliability coefficient
1	**Adaptive Learning**	The Nature of Adaptive Learning	5	0.975
		Knowledge of Adaptive Learning	5	0.972
		Adaptive Learning Development by using Microservices	5	0.982
First subject reliability - Adaptive Learning			15	0.990
2	**Using Microservices**	Using Microservices for enhancing Quality of Adaptive Learning	5	0.979
		Using Microservices for Lowering Cost of Adaptive Learning	5	0.976
		Using Microservices for enhancing Performance of Adaptive Learning	5	0.969
Second subject reliability - Microservices			15	0.992
The questionnaire reliability of all paragraphs			30	0.995

5.8 Statistical Data Processing

To process the collected and statistically analyzed data, the Statistical Package for Social Sciences (SPSS) version 25 was used for all these research aspects.

The statistical tools which were used to answer the study questions are:

- **Arithmetic Mean** was calculated in order to recognize the study sample high or low opinions regarding each basic research variable paragraph and the main areas, and to arrange the targeted people's responses to the questionnaire paragraphs according to the agreement level and the highest arithmetic mean average. [19]

Equation: 2 Arithmetic Mean Formula $$\overline{x} = \frac{\sum \text{Xi}}{n} \quad (2)$$

Where: $\overline{x}$ = Mean, $\sum x$= Summation of sample values, i varies from 1 to n, n= Number of sample values

- **Standard Deviation** was used for considering targeted sample responds to determine its homogeneity regarding their agreement averages and to adopt the following criterion (an estimated balance according to the five Likert scale): [20]

Table 3 : Arithmetic Mean Level

Level	Degree
Very high level	> 4.21
High level	< 4.20 or > 3.41
Neutral level	< 3.40 or > 2.61
Low level	< 2.60 or > 1.81
Very low	> 1.80

Equation 3 : Standard Deviation Equation $$\sigma = \sqrt{\frac{\sum(x-\overline{x})^2}{n-1}} \quad (3)$$

Where: x= The Value in the data distribution, x̄= Sample Mean, n= Total number of observations

Table 4: Standard Deviation Level

Level	Total Degree
Very high level	> .550
High level	<.549 or > .444
Neutral level	< .443 or > .340
Low level	< .339 or > .236
Very low	> .235

- Frequencies and percentages were used to find out the sample response level of each study variable paragraph.

5.9 Study questions analysis:

The following includes a complete and detailed study results presentation, analysis and statistical interpretation. The means, standard deviation, and the study sample response homogeneity degree regarding their questionnaire answers means are illustrated in Table 5 that presents all means, standard deviations and study aspects homogeneity degree, which analyzed as follows:

- **The Nature of Adaptive Learning** : Targeted people satisfaction mean is (4.75), the standard deviation is (0.550), and the degree of homogeneity is very high.
- **Knowledge of Adaptive Learning** : Targeted people satisfaction mean is (4.68), the standard deviation is (0.618), and the degree of homogeneity is very high.
- Adaptive Learning Development by using Microservice: Targeted people satisfaction mean is (4.67), the standard deviation is (0.631), and the degree of homogeneity is very high.

Regarding the Adaptive Learning total paragraphs, targeted people satisfaction mean is (4.70), the standard deviation is (0.590), and the degree of homogeneity is very high.

- **Using** Microservices for enhancing Quality of Adaptive Learning: Targeted people satisfaction mean is (4.75), the standard deviation is (0.554), and the degree of homogeneity is very high.
- Using "Microservices" for Lowering Cost of Adaptive Learning: Targeted people satisfaction mean is (4.75), the standard deviation is (0.547), and the degree of homogeneity is very high.

Table 5- Arithmetic Means , Standard Deviation and study sample response homogeneity degree

S	Study subjects	Dimensions	Mean	Std. Deviation	Homogeneity degree
1	**Adaptive Learning**	The Nature of Adaptive Learning	4.75	.550	Very high
		Knowledge of Adaptive Learning	4.68	.618	Very high
		Adaptive Learning Development by using Microservices	4.67	.631	Very high
Total paragraphs in the first subject- Adaptive Learning			4.70	.590	Very high
2	**Using "Microservices"**	Using "Microservices" for enhancing Quality of Adaptive Learning	4.75	.554	Very high
		Using "Microservices" for Lowering Cost of Adaptive Learning	4.75	.547	Very high
		Using "Microservices" for enhancing Performance of Adaptive Learning	4.74	.542	Very high
Total paragraphs in the second subject- Using "Microservices"			4.75	.545	Very high

- Using Microservices for enhancing Performance of Adaptive Learning: Targeted people satisfaction mean is (4.74), the standard deviation is (0.542), and the degree of homogeneity is very high.

Regarding the Using Microservices total paragraphs, targeted people satisfaction mean is (4.75), the standard deviation is (0.545), and the degree of homogeneity is very high.

5.10 Examining the Study Hypotheses

The First Hypothesis (There is a statistical relation between enhancing Adaptive Learning System and using "Microservices")

In order to validate the First Hypothesis, the Pearson Correlation coefficient is applied to illustrate the relation between enhancing Adaptive Learning and using Microservices

.

Equation 4 : Pearson correlation coefficient

$$r = \frac{n\sum x_i y_i - (\sum x_i)(\sum y_i)}{\sqrt{[n\sum x_i^2 - (\sum x_i)^2][n\sum y_i^2 - (\sum y_i)^2]}} \quad (4)$$

Where:

x_i, y_i = the variables value indexed with i,
x=first variable value
y=second variable value, and
n = number of sample values

The Pearson correlation coefficient (r) is the most common way of measuring a linear correlation. Revised on December 5, 2022, it is a number between –1 and 1 that measures the strength and direction of the relationship between two variables as shown in equation 4. When one variable changes, the other variable changes in the same direction. [21]

Table 6 : Pearson correlation coefficient

Pearson correlation coefficient (*r*) value	Strength	Direction
Greater than .5	Strong	Positive
Between .3 and .5	Moderate	Positive
Between 0 and .3	Weak	Positive
0	None	None
Between 0 and –.3	Weak	Negative
Between –.3 and –.5	Moderate	Negative
Less than –.5	Strong	Negative

Table 7 illustrates the correlation between the two main variables, namely enhancing Adaptive Learning and using "Microservices". Pearson Correlation coefficient equals (0.960) at the calculated significance level (.000) which is less than the above determined level (0.05 ≥ a). This indicated that there is a positive statistical correlation between the two variables.

Table 7 - Correlation between the two main variables (Independent & Dependent)

Correlations			
		Enhancing Adaptive Learning	**Using Microservices**
Enhancing Adaptive Learning	**Pearson Correlation**	**1**	**0.960****
	Sig. (2-tailed)		**0.000**
	N	**377**	**377**
Using Microservices	**Pearson Correlation**	**0.960****	**1**
	Sig. (2-tailed)	**0.000**	
	N	**377**	**377**
****. Correlation is significant at the 0.01 level (2-tailed).**			

The second hypothesis: Impact of using "Microservices" for enhancing Adaptive Learning System in Egyptian Petroleum Sector by providing better performance, high quality and lowering the cost

This hypothesis was confirmed by four steps, as shown below:

The first step (Determine the method used): The least-squares method was applied in the linear regression analysis, where the independent variable is using Microservices and the dependent variable is enhancing Adaptive Learning as shown in Table 8.

Table 8 - The linear regression analysis method

Variables Entered/Removed[a]			
Model	**Entered**	**Variables Removed**	**Method**
1	**Enhancing Adaptive Learning**	**0**	**Enter**
a. Independent variable: Using Microservices			
b. All requested variables entered.			

The second step (linear correlation):

It shows the result of calculating the linear correlation coefficient R and the coefficient of determination, R square, where the linear correlation coefficient between the variables is .960 and the accuracy of estimating the dependent Variable (enhancing Adaptive Learning) is .922. As shown in Table 9.

So, the linear correlation coefficient that is greater than zero and indicates a positive and strength relationship between the two variables.

Table 9 - Linear correlation between the variables

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.960[a]	.922	0.921	.15280	0.922	4411.579	1	375	0.000
a. Predictors: (Constant), Enhancing Adaptive Learning									

The third step (Analysis of variance "ANOVA"): -

It shows the degree of the data linear regression in Table 10.

1- The sum of regression squares equal (102.994). The sum of residual squares (8.775) and the total sum is (111.749).
2- Regression degree of freedom df equals 1, and the residual degree of freedom equals 375, and the total df equals 376 degrees provided that (df= n – 1).
3- Regression squares mean is (102.994) and the residual squares mean is .023.
4- The analysis of variance for the regression line equals 4411.579.
5- The significance level, .000, is less than the null hypothesis significance level, 0.005, thus it is rejected, and the regression line matches the data.

Table 10 - Analysis of variance " ANOVA "

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	102.994	1	102.994	4411.579	.000[b]
	Residual	8.755	375	.023		
	Total	111.749	376			
a. Dependent Variable: Enhancing Adaptive Learning						
b. Predictors: (Constant), Using Microservices						

The fourth step (The Coefficients for proving the hypotheses of the study): -

It shows some outcomes. The slope value and B are first, followed by the hypotheses that have been applied with a certain slope and B, where B = (.583). B is equivalent to (.886) for the independent variable (Microservices). As seen in Table 11)

The results of the t test for the independent variable equals (66.420) and B equals (9.206) for the regression line slope hypothesis.

Upon looking at the significance levels, it is clear that the result is acceptable since it supports the study's hypotheses by showing that the significance level is lower than the null hypothesis's significance level, which is set at 0.05.

Table 11 - The Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.583	.063		9.206	. 000
	Using Microservices	.886	.013	.960	66.420	.000
a. Dependent Variable: Enhancing Adaptive Learning						

6. Results and Discussion

6.1 Results From the target group's personal data description.

1. Males made up 89.9% of the targeted group, which is the highest percentage.

2. The average age groupings show that those between the ages of 30 and 39 make up the highest number, with a percentage of 39%.

3. Out of the total number of persons targeted, those with a university degree had the highest proportion of credentials (59.7%), and those with a technician job had the highest employment rate (44.8%).

4. Of the sample, 94.2% accepted the offer to use an adaptive learning service, which was the highest proportion.

5. In terms of the Job Description, Administrators made up the biggest number with a 43.2% rate.

6.2 Results of Examining the Study Hypotheses.

1- According to Stephen Thompson's equation, the study's sample is identical with the community size.

2- Generally, the Study reliability are statistically acceptable according to Cronbach's Alpha Reliability Analysis, and the results showed that the general reliability of the questionnaire subjects was very high, as it reached (.995) out of the total number of the paragraphs which are 30 paragraphs, and the reliability for the study variables scale ranged between (.969 - .982). According to Nanli scale, they are statistically acceptable reliability, which adopted (0.70) as a minimum stability.

3- While analyzing the study's questions, it shows high percentages of the arithmetic mean and standard deviation, and according to the responses of the sample members, the homogeneity degree was very high.

4- Pearson Correlation coefficient was used to clarify the relationship between the study's subjects, and a sign that there is a positive correlation with a statistical significance between enhancing Adaptive Learning and Using cloud computing services "Microservices ".

5- Linear correlation coefficients were calculated to identify the effect of enhancing of Microservices on enhancing Adaptive Learning in Egyptian Petroleum Sector. The linear correlation coefficients variables were .960, and the extent of accuracy in estimating the variable related to (enhancing Adaptive Learning) is .922.

6- Because the significance level of 0.000 is less than the significant level 0.005, there is a statistically significant association, and the analysis of variance ANOVAa result demonstrated that there is an effect between the study's variations.

7- The results of the test T on the hypothesis regression of ANOVAa slope of the study's variables, Sig. Values, and the values of the slope and regression of ANOVAa. Because the numbers support the study's hypothesis and the significance level of the test is less than 0.05, the researcher concluded that the values are acceptable.

7. Conclusion

According to the positive results of the study that was covered for the impact of enhancing the performance, quality and lowering cost of the ALS by using the Microservices, the following research hypothesis are accepted:

Statistically speaking, there is a strong correlation between adaptive learning and microservices.

There is a significant impact on using Microservices for enhancing Adaptive Learning in Egyptian Petroleum Sector.

References

[1] Shelle, G., Earnesty, D., Pilkenton, A. & Powell E., "Adaptive Learning: An Innovative Method for Online Teaching and Learning", Extention Journal Inc., 2018, vol. 56, no. 5.

[2] Tan, C., "Adaptive Learning Recommendation Strategy Based on Deep-Q-Learning", Applied Psychological Measurement, 2020, Vol. 44(4) , pp. 251–266.

[3] Pachghare, V., "Microservices Architecture for Cloud Computing", Journal of Information Technology and Sciences, 2016, Volume 2 Issue 1, India.

[4] Pahl, C. & Lee, B., "Containers and clusters for edge cloud architectures - a technology review", 3rd International Conference on Future Internet of Things and Cloud, 2015.

[5] Flower, J. & Lewis M., "http://martinfowler.com/articles/", 2014. [Online].

[6] Atman, N., "https://developer.oracle.com › Microservices", 2020. [Online].

[7] Morze, N., Trotsenko, L., Terletska, T. & Trybulska, E., "Implementation of adaptive learning at higher education institutions by means of Moodle LMS", Journal of Physics: Conference Series, 2021.

[8] Wang, S., Christensen, C., Cui, W. &Tong, R., "When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction", International Learning Environment Article, 2020.

[9] Mirata, V., Hirt, V., Bergamin, P. & Van der Westhuizen, C., "Challenges and contexts in establishing adaptive learning in higher education: findings from a Delphi study," International Journal of Educational Technology in Higher Education, Netherlands, 2020.

[10] Amaral, M., Polo, J., Carrera, D., Mohomed, I. & Unuvar, M., "Performance Evaluation of Microservices Architectures using Containers," IEEE 14th Internaional Synposium Conference on Network Coputing and Applicaions, 2015.

[11] Metzig A., "Elasticity Concept for a Microservice-based System", Master Thesis, Nürnberg: Friedrich-Alexander-Universität Erlangen, 25 February 2022.

[12] De Iasio, A., & Zimeo, E. , "A framework for Microservices synchronization," Software Practice and Experience, 2020, vol. 51, no. 1, pp. 25-45.

[13] Shabani, I., Mëziu, E., Berisha, B. & Biba, T., "Design of Modern Distributed Systems based on

Microservices Architecture", International Journal of Advanced Computer Science and Applications, 2021, Vol. 12, , no. No. 2.

[14] Helmy, A., Eliemy, M. &. Abdelhalim, A., "Performance & Quality of Adaptive Learning Systems Survey", IEEE SEM Journal, 2022, vol. 10, no. 1.

[15] Binildas, C., "Practical Microservices Architectural Patterns", Apress, USA, 2019.

[16] Megargel, A., Poskitt, C. and Shankararaman V., "Microservices Orchestration vs. Choreography: A Decision Framework", IEEE, 2021.

[17] Reddy Peddireddy, K. & Nidamanuri, S., "Requirements Validation Techniques and Factors Influencing them" 2021. [Online]. Available: www.diva-portal.org .

[18] Aldesouky, M., "The results of the fifth economic census ,private sector", Economic activity and governorates, Central Agency for Public Mobilization and Statistics, Egypt, 2017/2018.