# Performance & Quality of Adaptive Learning Systems Survey

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## Abstract

Adaptive Learning Systems (ALSs) provide an efficient, effective and customized learning experience for learners by dynamically adapting learning content to suit their individual abilities or preferences.

The enhancements and improvements in adaptive learning systems need to 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 no 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.

In this paper, Microservice & functions as a services architecture are presented, also the serverless platform, Virtualization platform, and finally the results and conclusions are discussed.



**Keywords**: Adaptive Learning System, Miroservice Architecture, Virtualization Technology, Function as a Service, Serverless Computing Architecture, Adaptive Learning Environment.

## 1. Introduction

Adaptive learning is an important aspect in many fields. It refers to an educational method that delivers personalized educational interventions, typically implemented through computerized algorithms that output personalized action recommendations based on analysis of the learning histories of the learners. [1]

Adaptive learning systems (ALSs) aim 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.

Adaptive learning systems offer personalized learning experience to students' characteristics and abilities. Previous Studies showed that these systems could be effective learning tools. Many training providers have adopted their adaptive learning systems.

The processing of the Adaptive Learning Systems facing a problem of longer time of running processes, shortage of scalability and reliability of functions done through Adaptive Learning Systems. [2]

In this paper, we present microservice architecture as a new technology, which its main objective is to break up application architectures into independently deployable services that can rapidly deployed to any infrastructure resource as required, in order to develop and enhance the adaptive learning platform for trainees and trainers,

As the new trends in various areas are emerged day by day, the new architecture for various applications is evolving. There is a demand from users for interactive, rich and dynamic experience on various platforms. These demands are satisfied by the applications having high availability, scalability and easy-to-execute on cloud platform. Most of the organizations want to update their applications frequently, several times a day. Monolithic applications have the

limitation to support such demands. The Microservices architecture can support and achieve above requirements. The applications with this new architecture have multiple services which can deploy independently. These services focus on a minor part of the applications. Microservices provide scalability and agility to the applications. [3]

In the cloud, Microservices are linked to containers, which are a lightweight virtualization mechanism used for application packaging, distribution and orchestration at the PaaS layer, even towards edge clouds with smaller resource environments [4].

Though Service Oriented Architecture (SOA) has become popular in the integration of multiple applications using the enterprise service bus, there are few challenges related to delivery, deployment, governance, and interoperability of services. Additionally, the services in SOA applications are tending towards monolithic in size with the increase in changing user requirements. To overcome the design and maintenance challenges in SOA, Microservices has emerged as a new architectural style of designing applications with loose coupling, independent deployment, and scalability as key features. [5]

In the cloud computing, using Faas and its Microservices category; Platform will enhance and improve code maintenance, enables easier scalability and improves the reliability of the Adaptive Learning Systems.

In FaaS system, the functions expected to start within milliseconds in order to allow handling of individual requests. In PaaS systems, by the contrast, there is typically an application thread, which keeps running for a long period and handles multiple requests.

The purpose of the paper is to determine the essence of cloud-based adaptive learning systems by using the platform of Microservice, the state of the art of their use in education, outline the prospects for their development and implementation. Microservice architectures used to break up application architectures into independently deployable services that will rapidly deployed to Micreservice infrastructure resource as required.

This paper aims to apply the adaptive learning systems using the cloud computing in any sector with the benefits of using FaaS that the functions are expected to start rapidly in order to allow handling of individual requests by using the Microservice Architecture. Microservice will support ALS with availability, good performance, On-Demand, Pay per use, wide network access and rapid elasticity.



Microservices are about functional decomposition enables for instance agility, flexibility and scalability. Distributed systems provide a shift from traditional ways of building systems where the whole system is concentrated in a single and indivisible unit. The latest architectural changes are progressing toward Microservices. The monolithic systems, which can be considered as ancestors of Microservices, cannot fulfill the requirements of today's big and complex applications. [6]

With the Microservice Architecture (MSA) style, an application is designed as a set of business-driven Microservices that can be developed, deployed, and tested independently. MSA follows a "share-as little- as-possible" architecture approach and communicates with each other through an API layer. In contrast, SOA adopts a "share-as-much-as-possible" architecture approach and typically uses the Enterprise Service Bus for communication purpose. Another key difference between MSA and SOA is that MSA advocates one data storage per microservice, while SOA uses one data storage for the whole system. Moreover, the systems that adopt the MSA style (i.e., Microservices systems) have a better fault-tolerance than SOA-based systems. The advantages of the MSA style are enormous, and the key drivers of adopting MSA are faster delivery, improved scalability, and greater autonomy compared to other architectural styles (e.g., SOA) [7]

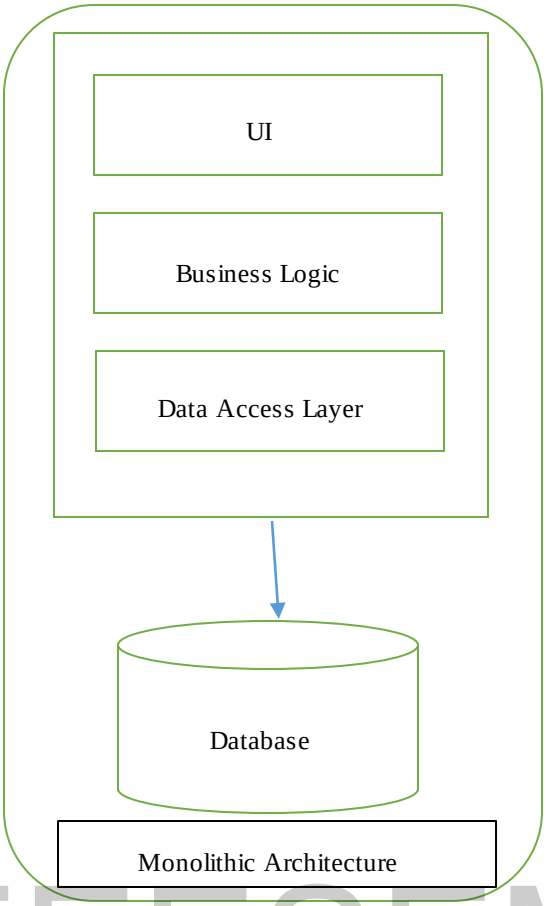




Figure 1 Monolithic System Architecture

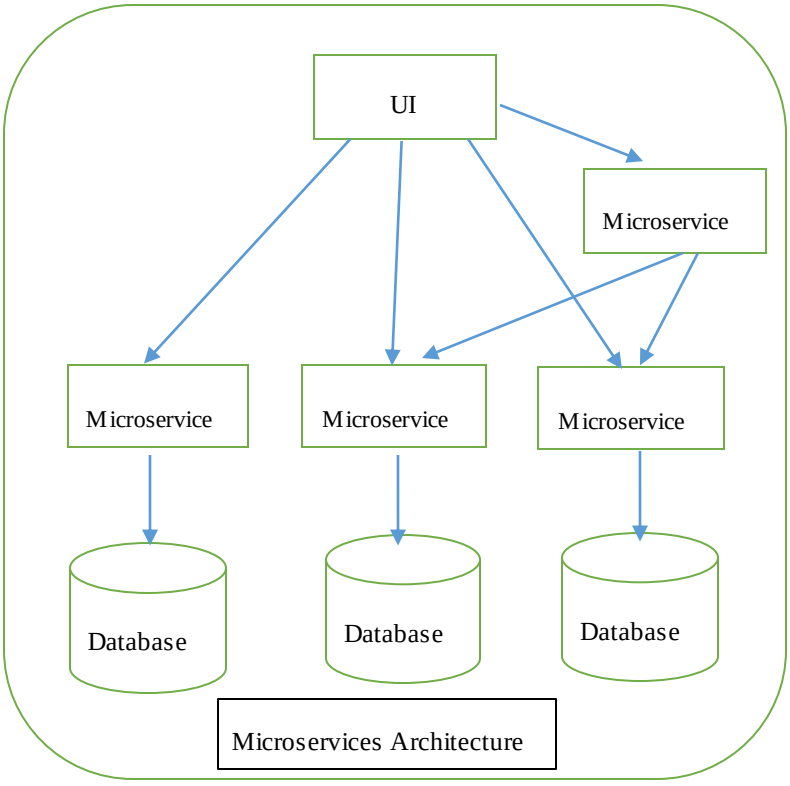


Figure 2 Microservice System Architecture

A visual comparison of a Microservice system versus a Monolithic one is represented as shown in Figure 1 and Figure 2. Should a Microservice fail, it would not compromise the overall system.

In Monolithic architecture, a single code is used for all the components of AL application and the code is large which makes it difficult to understand. Also, the scaling of this architecture is difficult, the Integration and deployment of the system are more complex and time consuming. The Integrated Development Environment (IDE) may be overloaded due to the large size of code and makes the IDE slow and increases in the time for building the application, and finally, every component is tightly coupled which makes it difficult to change the language, framework or technology. [8]

Microservices are designed to combat the rigidness of the monolithic interwoven structure. This implies that when designing Microservices, each Microservice should remain independent of its other services. By remaining independent, the Microservice would not drag down the system when it eventually fails.

Virtualization technology boosts up traditional computing concept to cloud computing by introducing Virtual Machines (VMs) over the Physical Machines (PHs) when designing ALS, which enables the cloud service providers to share the limited computing and network resources among multiple users. Virtual resource mapping can be defined as the process of enabling multiple VMs and their network resource demand onto multiple inter-connected PMs. The existing mechanisms of resource mapping need to be efficient enough to minimize the number of PMs without compromising the deadline of the tasks assigned to the VMs.

The development and realization of distributed energy data storage and control application based on cloud technologies. The LAN is built by cloud connected devices. The developed applications utilize Microservices based architecture, which improves code maintenance, enables easier scalability and improves the reliability of the system.

Learners will have access to development platform, and develop their own applications and store on a certain sector infrastructure. In this way, lecturers will focus their basic tasks and not lose their workforce.



FaaS (Function as a Service) in the cloud computing services will provide the platform in the ALS and allowing developing, running and managing application functionalities without the complexity of building and maintaining the infrastructure typically associated with developing and launching an application. Building an application following one way of achieving a “Serverless” architecture, and is typically used when building Microservices applications.

Serverless computing architecture in which the training providers has no direct need to manage resources achieved using PaaS services “Platform as a service”. These services are, however, typically very different in their implementation architecture which has some implementations for scaling.

In PaaS systems the system continually runs at least one server process and even with auto scaling a number of longer running processes are simply added or removed meaning that scalability is more visible to the developer as a problem.

## 2. Methodology

There are sequential phases, where the first one is about getting started and identifying an intellectual interest. The next phases are dedicated to gathering literature relevant to the intellectual interest and examining the select studies with proper attention to details so that the texts can be suitably created. Determining how the studies are related to each other so that key concepts may be compared is the theme of the phase which is followed by a phase that involves translation of the studies into one another based on found analogies. In the phase, translations are created such that important concepts are grouped and passed on to the final phase where the created findings are concisely expressed.

### *2.1 Identification of Relevant Studies*

As mentioned previously, the intellectual interest of our study is to identify the key dimensions that constitute a mature Adaptive Learning System. To meet that objective, we explored the extant literature to identify relevant studies in the field. First, we conducted a search using the term 'Adaptive Learning' on Google Scholar and scanned the first hundred search results to list down the commonly used related terms such as 'Adaptive Learning Systems', 'Adaptive Learning Tools' and 'Adaptive Learning Models' for Adaptive Learning; and 'development model', 'stage model' and 'phase model' for maturity model. Then, we conducted another round of search on three databases – Sagepub, Science Direct, Springer and Google Scholar – with a combination of terms, namely 'Adaptive Learning' or a related term, and 'maturity model' or a related term between 2015, and 2021. A total of 256 papers were identified after eliminating the duplications.

### *2.2 Selection of Studies*

After examining the abstracts of the 256 identified papers, we filtered out 214 papers. Further, after going through the full text of the remaining 42 papers, 23 of them were excluded from the study. Therefore, a total of 237 papers were excluded based on the following exclusion criteria:

- not available online,
- not published in a peer-reviewed journal,
- not focusing on proposing or developing an Adaptive Learning maturity model,
- not applicable to the context of our study.

A couple of studies that are excluded from the sample after careful consideration may illustrate how the last two exclusion criteria are applied. First, one study suggested several tips for successfully designing and implementing Adaptive Learning initiatives. However, the study was excluded from the sample for not proposing or developing a maturity model. Second, another study developed a comprehensive model to measure user satisfaction in the case of Adaptive Learning services, which essentially differs from an Adaptive Learning maturity model. At the completion of the exclusion process, we searched the lists of references of the nineteen shortlisted papers and discovered eight reports relevant to our research objective, authored by the practitioners. Thus, we finally had a total of 25 relevant publications.



### *2.3 Collection of Key Concepts*

Carefully examining the select papers and reports, we found that the number of stages included in the maturity models may range from two to six. For example, N Morze et al. [9] , Yanan Li et al [10], Kateryna Osadcha [11], Victoria Mirata [12], Hassan Khosrav [13], Maiia Marienko [14] and Yuliya H. Nosenko [10] proposed a maturity model with two, three, four, five and six stages, respectively. The focus areas or the constructs of each stage proposed by each of the studies are presented in table 1 to table 7. Interestingly, initial attempts to develop Adaptive Learning Performance & Quality are also presented.

## ALS Survey Comparative Analysis

### Table 1 Names of Approaches, Journals, Conferences & Web-Sites

The following table includes 25 references used in the paper concerning the Adaptive Learning published journals, conferences and web-sites which used to prove that we need new technology to enhance the current ALS.

| SN | Approach | Year | Name |
|---|---|---|---|
| 1 | N Morze et al. [9] | 2021 | Journal of Physics: Conference Series |
| 2 | Yanan Li et al [15] | 2021 | MDPI Journal |
| 3 | Ahmet Dogukan Sarıyalçınkaya et al. [16] | 2021 | https://www.researchgate.net/publication/348716769 |
| 4 | Kateryna Osadcha [11] | 2020 | Creative Commons License Attribution 4.0 International |
| 5 | Victoria Mirata [12] | 2020 | International Journal of Educational Technology in Higher Education |
| 6 | Hassan Khosrav [13] | 2020 | Technical Symposium on Computer Science Education Conference |
| 7 | Maiia Marienko [14] | 2020 | E3S Web of Conferences Journal |
| 8 | Yuliya H. Nosenko [10] | 2019 | Creative Commons License Attribution 4.0 International |
| 9 | Meng-Leong HOW [17] | 2019 | MDPI Journal |
| 10 | Peyman Akhavan [18] | 2018 | 19th European Conference on Knowledge Management |
| 11 | Xinghua Wang [19] | 2018 | Journal of Educational Computing |
| 12 | Sucheta Kolekar [20] | 2018 | 3rd. International Conference on Computer Science and Computational Intelligence |
| 13 | Christos Chrysoulas [21] | 2018 | Academic Network of Loc Nguyen Conference |
| 14 | Polina M. Vanyukov et al [22] | 2018 | https://doi.org/10.3758/s13415-019-00697-0 |
| 15 | Chuck Dziuban [23] | 2018 | Online Learning Journal |
| 16 | Oleksandr Yu. et al. [24] | 2018 | Information Technologies and Learning Tools |
| 17 | Shirin Mojarad [25] | 2018 | International Conference on Learning Analytics & Knowledge |
| 18 | Benjamin D. Nye [26] | 2018 | International Journal of STEM Education |
| 19 | Levent Çetinkaya [27] | 2018 | World Journal on Educational Technology |
| 20 | Min Liu [28] | 2018 | Association for Educational Communications and Technology |
| 21 | Chun-Hui Wu [29] | 2018 | EURASIA Journal of Mathematics, Science and Technology Education |
| 22 | M. Rani [30] | 2018 | Journal of Engineering Education |
| 23 | Benjamin D. et al [31] | 2018 | International Journal of STEM Education |
| 24 | Abdel Fatah Hegazy [32] | 2018 | International Conference on Communication Management and Information Technology (ICCMIT) |
| 25 | Sucheta Kolekar [33] | 2018 | 3rd International Conference on Computer Science and Computational Intelligence |

### Table 2 Ease of Use & Flexibility Dimension

The following table represents the Ease Of Use & Flexibility and the related components (Cloud Computing- Adaptive Learning Systems – On Demand) which mentioned to the **star symbol (*)** if it were important to be discussed and included in the research or not.

| SN | Approach | Year | Cloud Computing | Adaptive Learning Systems | On Demand |
|---|---|---|---|---|---|
| 1 | N Morze et al. [9] | 2021 | | * | |
| 2 | Kateryna Osadcha [11] | 2020 | | * | |
| 3 | Victoria Mirata [12] | 2020 | | * | * |
| 4 | Hassan Khosrav [13] | 2020 | | * | * |
| 5 | Maiia Marienko [14] | 2020 | * | * | * |
| 6 | Yuliya H. Nosenko [10] | 2019 | * | * | |
| 7 | Meng-Leong HOW [17] | 2019 | | * | * |
| 9 | Peyman Akhavan [18] | 2018 | | * | |
| 10 | Xinghua Wang [19] | 2018 | | | * |
| 11 | Sucheta Kolekar [20] | 2018 | | | * |
| 12 | Christos Chrysoulas [21] | 2017 | * | * | |

**Table 3 Support Learning Material/ Service Dimension**

The following table represents the Support Learning Material/ Service and the related components (material availability – material quality- support management systems) which mentioned to the **star symbol (*)** if it was important to be discussed and included in the research or not.

| SN | Approach | Year | Availability | Material Quality | Support Management Systems |
|---|---|---|---|---|---|
| 1 | Ahmet Dogukan Sarıyalçınkaya et al. [16] | 2021 | | * | |
| 2 | Kateryna Osadcha [11] | 2020 | * | | |
| 3 | Victoria Mirata [12] | 2020 | * | * | * |
| 4 | Hassan Khosrav [13] | 2020 | * | * | |
| 5 | Maiia Marienko [14] | 2020 | | | * |
| 6 | Yuliya H. Nosenko [10] | 2019 | * | | |
| 7 | Polina M. Vanyukov et al [22] | 2019 | | * | |
| 8 | Chuck Dziuban [23] | 2019 | * | | |
| 9 | Peyman Akhavan [18] | 2018 | | | * |
| 10 | Oleksandr Yu. Burov [24] | 2018 | * | | |
| 11 | Shirin Mojarad [25] | 2018 | | * | |
| 13 | Benjamin D. Nye [26] | 2018 | * | * | |
| 14 | Xinghua Wang [19] | 2018 | | * | |
| 15 | Levent Çetinkaya [27] | 2018 | * | | |
| 16 | Christoph Fröschl [21] | 2018 | | | * |



**Table 4: Learning Quality Dimension**

The following table represents the dimension of the survey called Learning Quality and the approach name and the related components (Quantification - Participants) which mentioned to the **star symbol (*)** if it was important to be discussed and included in the research or not.

| SN | Approach | Year | Quantification | Participants |
|---|---|---|---|---|
| 1 | Kateryna Osadcha [11] | 2020 | * | |
| 2 | Maiia Marienko [14] | 2020 | * | * |
| 3 | Polina M. Vanyukov et al [22] | 2019 | | * |
| 4 | Meng-Leong HOW [17] | 2019 | * | * |
| 5 | Chuck Dziuban [23] | 2019 | * | * |
| 6 | Shirin Mojarad [25] | 2018 | | * |
| 7 | Benjamin D. Nye [26] | 2018 | * | * |
| 8 | Xinghua Wang [19] | 2018 | * | * |
| 9 | Min Liu [28] | 2017 | * | * |
| 10 | Chun-Hui Wu [29] | 2017 | * | * |
| 11 | M. Rani [30] | 2015 | * | * |

**Table 5 : Learning Performance Dimension**

The following table represents the dimension of the survey called Learning Performance and the approach name and the related components (Learner Evaluation- Learner Progress & Runtime- Learning Services- Learning Framework) which mentioned to the **star symbol (*)** if it were important to be discussed and included in the research or not.

| SN | Approach | Year | Learner Evaluation (Quantification) | Learner Progress & Runtime | Learning Services | Learning Framework |
|---|---|---|---|---|---|---|
| | Ahmet Dogukan Sarıyalçınkaya et al. [16] | 2021 | * | * | | * |
| 1 | Kateryna Osadcha [11] | 2020 | | * | * | * |
| 2 | Victoria Mirata [12] | 2020 | | * | * | * |
| 3 | Hassan Khosrav [13] | 2020 | * | | | * |
| 4 | Maiia Marienko [14] | 2020 | * | | * | |
| 5 | Yuliya H. Nosenko [10] | 2019 | | | * | |
| 6 | Polina M. Vanyukov et al [22] | 2019 | | | | * |
| 7 | Meng-Leong HOW [17] | 2019 | * | * | * | * |
| 8 | Oleksandr Yu. Burov [24] | 2018 | | | * | * |
| 9 | Shirin Mojarad [25] | 2018 | * | * | * | |
| 10 | Benjamin D. Nye [26] | 2018 | * | * | * | * |
| 11 | Benjamin Doerr [31] | 2018 | * | * | | * |
| 12 | Levent Çetinkaya [27] | 2018 | * | * | | |
| 13 | Abdel Fatah Hegazy [32] | 2015 | * | * | | |
| 14 | M. Rani [30] | 2015 | * | * | * | |



**Table 6 System Resource Management Dimension**

The following table represents the dimension of the survey called System Resource Management and the approach name and the related components (Microservices - Computing Resources – Network Resources – Resource Scaling)) which mentioned to the **star symbol (*)** if it were important to be discussed and included in the research or not.

| SN | Approach | Year | Computing Resources | Network Resources | Resources Scaling |
|---|---|---|---|---|---|
| 1 | Yanan Li et al [15] | 2021 | * | * | |
| 2 | Kateryna Osadcha [11] | 2020 | | | * |
| 3 | Victoria Mirata [12] | 2020 | | * | |
| 4 | Hassan Khosrav [13] | 2020 | * | | * |
| 5 | Maiia Marienko [14] | 2020 | * | * | |
| 6 | Yuliya H. Nosenko [10] | 2019 | | | * |
| 7 | Polina M. Vanyukov et al [22] | 2019 | | | |
| 8 | Meng-Leong HOW [17] | 2019 | * | | |
| 9 | Chuck Dziuban [23] | 2019 | | * | |
| 10 | Peyman Akhavan [18] | 2018 | * | | * |
| 11 | Oleksandr Yu. Burov [24] | 2018 | * | | * |
| 12 | Shirin Mojarad [25] | 2018 | | | |
| 13 | Benjamin D. Nye [26] | 2018 | | | * |
| 14 | Xinghua Wang [19] | 2018 | * | * | |
| 15 | Chun-Hui Wu [29] | 2017 | * | * | |

**Table 7 Infrastructure Technology Dimension**

The following table represents the first dimension of the survey called Infrastructure Technology and the approach name and the related components (Microservices – Software Technology – Web Service – Cloud Computing) which mentioned to the **star symbol (*)** if it were important to be discussed and included in the research or not.

| SN | Approach | Year | Microservice | Software Technology | Web Service | Cloud Computing |
|---|---|---|---|---|---|---|
| 1 | Ahmet Dogukan Sarıyalçınkaya et al. [16] | 2021 | | | * | |
| 2 | Kateryna Osadcha [11] | 2020 | | * | | |
| 3 | Victoria Mirata [12] | 2020 | | | * | |
| 4 | Hassan Khosrav [13] | 2020 | | * | | |
| 5 | Maiia Marienko [14] | 2020 | | | | * |
| 6 | Yuliya H. Nosenko [10] | 2019 | | | | * |
| 7 | Polina M. Vanyukov [22] | 2019 | | * | | |
| 8 | Meng-Leong HOW [17] | 2019 | | * | | |
| 9 | Chuck Dziuban [23] | 2019 | | * | | |
| 10 | Peyman Akhavan [18] | 2018 | | * | | |
| 11 | Christoph Fröschl [21] | 2018 | | * | | |
| 12 | Sucheta Kolekar [33] | 2018 | | * | | |
| 13 | Abdel Fatah Hegazy [32] | 2015 | | | * | * |

## 3. Related Work



In the related work, we founded that the infrastructure of adaptive learning systems need to be enhanced by using the Cloud Computing platform. We founded that ALS have advantages like ease of use; flexibility; availability and quality of supporting learning material/ service and the different types /styles. Although, learning quality & performance of services and participants in ALS should integrated with the Cloud Computing platform. Infrastructure technology should apply Cloud Computing platforms and function as a service Faas Platform through Microservice technology to increase the performance and quality of ALS.

Nowadays systems, in comparison with the elaborations of previous generations, configure better and faster in the process of work, characterized by the flexibility and openness to modifications. The authors mentioned also the essence to the quality of educational services and as the result the increase of intellectual potential of the society. [34]

The practical recommendations are very important for institutional leaders and project implementers on the factors to be considered when implementing adaptive learning in higher education settings. These recommendations relate to the necessary infrastructure, institutional commitment, support and resources, Accessibility & availability of necessary technical/physical infrastructure, Flexible functions of LMS & adaptive learning systems. They used questionnaire method "Delphi" allowed them to gain experts' collective opinion on such a complex phenomenon as adaptive learning in a structured but still flexible manner. [35]

Developing and piloting an ALS in a course on relational databases providing quality, scalable and content ALS relies on crowdsourcing and partnership with students for the development of learning resources that are adaptively served. [36]

ALS gained popularity in universities due to its flexibility and free distribution and one of such systems is Moodle LMS. That makes the question of implementation of adaptivity elements in Moodle relevant and many researchers have paid attention to this topic in recent decade. The advantages of e-learning as possibilities to hoose time for learning, perform tasks online, separate tasks into parts for completing them, return to mastered material and availability of various formats of materials. [9]

There are clear differences between the learning providers linked to different socioeconomic backgrounds and organisational contexts (e.g., type of the university, teaching

model, and implementation phase). Practical recommendations for institutional leaders and project implementers on the factors to be considered when implementing adaptive learning in higher education and learning providers' settings. These recommendations relate to the necessary infrastructure, institutional commitment, support and resources. [12]

Adaptive learning systems "RiPPLE" inviztes students to create and moderate learning resources; providing open and transparent models of learners that help students better understand their own learning needs and improve self-regulation; utilizing mechanisms such as gamification and other factors such as usability, flexibility and scalability. [13]

The use and elaboration of the adaptive cloud-based learning systems are essential to provide sustainable development of teachers' education. [14]

Adaptive Learning systems require computation of a very high order, analyzing enormous amounts of data in real time. So, the scalability of the system can be considered from effectively of program architecture to provide the processing, loading, distribution of these data. In view of this, the relevant and perspective point is to study the principles and approaches of designing the ALS on the basis of cloud platforms. [10]

Adaptive learning during social exchanges depends on tracking the success of one's approach (policy) toward the counterpart. When testing an alternative hypothesis, people learn from their interactions with others, encode prediction error updates with respect to their own policy. [22]

Artificial intelligence-enabled adaptive learning systems (AI-ALS) are increasingly being deployed in education to enhance the learning needs of students. Bayesian networks used to simulate predictive hypothetical scenarios with controllable parameters to better inform them about the suitability of the AI-ALS for the students. [17]

Computing learning resources (CCLR) are essential and important in underfunded, rural high schools to effective implementation for underprivileged students. [19]

## 4. Background



Using Faas and Microservices Platforms in the Adaptive Learning Systems will enhance and improve code maintenance, enables easier scalability and improves the reliability of the system.

In FaaS system, the functions expected to start within milliseconds in order to allow handling of individual requests of the adaptive learning systems. In PaaS systems, by the contrast, there is typically an application thread, which keeps running for a long period and handles multiple requests.

This difference is primarily visible in the pricing where PaaS services charge per execution time of the thread in which the server applications are running.

Considering the importance of education and learning for the development of creativity and sustainability of a city, SLE "Server-less Learning Environments" could regarded as a response to the needs of the new knowledge society.

SLEs engage and integrate formal and informal learning in order to create autonomous adaptive learning environments for supporting individual learners with real-time and seamless learning experiences in ubiquitous settings

Similar collaborative partnerships among learning providers and vendors is an important next step in the research process. Also it is a collaboration between them and their common adaptive learning platform provider. Each organization brings different strengths to the partnership. It achieves scale with adaptive implementation and integrates research and data into the decision-making and policy process. [23]

Data analysis showed that there is a strong relationship between the main components of knowledge management including creation, application and sharing; and adaptive e-learning components including management; evaluation and system security; Culture and human resources; learning paths and scenarios; learning objects and educational contents. [18]

ALEKS (Assessment and LEarning in Knowledge Spaces) is an adaptive learning system designed for courses in science and mathematics. The effectiveness of ALEKS at a community college, where have adopted ALEKS while others chose not to use it. Different possible comparisons using propensity score matching (PSM) by matching ALEKS and Non-ALEKS users across their Accuplacer score, age and race. In all comparisons, students using ALEKS have significantly higher pass rates than comparison groups. [25]

## 5. Cloud Computing Services Relationship with Adoative Learning

In order to help the trainees, trainers and administrators to better utilize their infrastructure for the Adaptive Learning Systems (ALS), we need to utilize the following platform in ALS and specify the service models (Iaas, Faas, Saas) of the cloud as follows:

**IaaS (Infrastructure as a Service)**

Iaas in ALS will provide the capability of provision processing, storage, networks and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

**FaaS (Function as a Service)**

Faas will provide the ALS with the Microservice architecture to break up the application architecture into independently deployable services that can rapidly deployed to any infrastructure resource as required. In addition, the functions are expected to start within milliseconds in order to allow handling of individual requests.

**SaaS (Software as a Service):**

SaaS will provide ALS with the software distribution model in which a third-party provider hosts applications and makes them available to the training providers over the Internet. SaaS is one of three main categories of cloud computing, alongside (IaaS) and (PaaS)



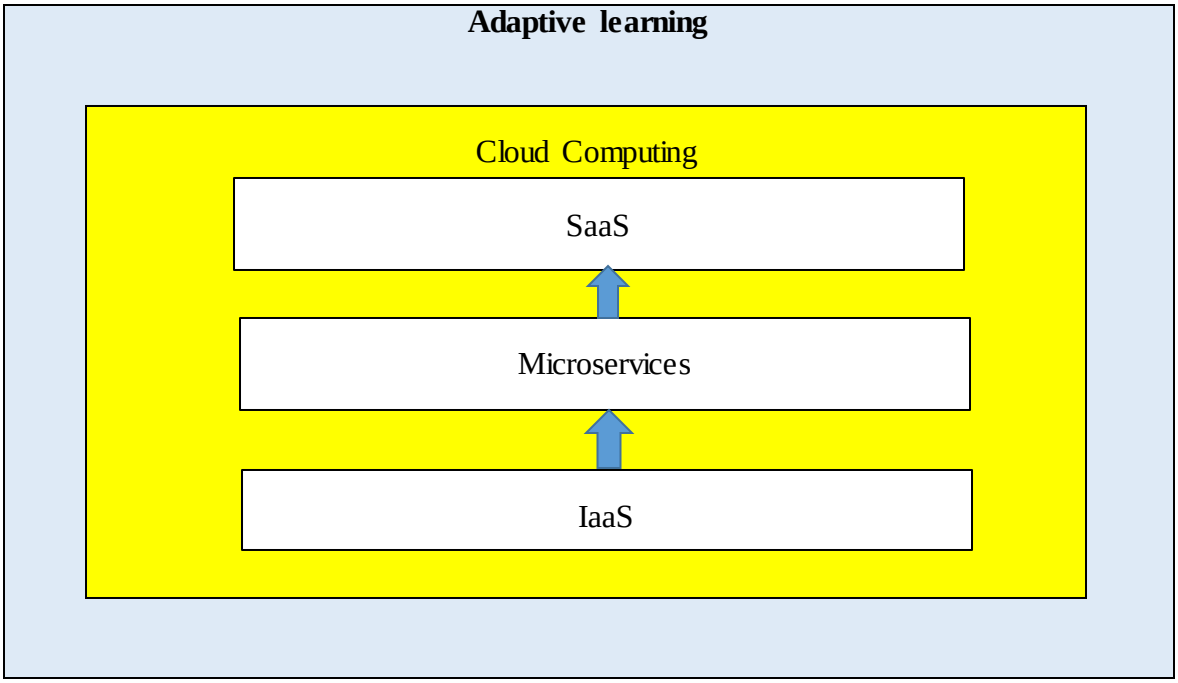


Figure 3 Cloud Computing Services Relation with Adoptive Learning

## 6. Results:

We found six dimensions of the comparative analysis of the ALS survey as follows:
- Ease of use & flexibility,
- Support Learning Material/ Services,
- Learning Quality,
- Learning Performance,
- System resource management and
- Infrastructure technology

No one of the previous studies mentioned to a new technology that may solve the problem of the current adaptive learning systems. The ALS processes take a long time due to 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. Microservice as a new technology in the cloud-computing platform will enhance the scalability, stability and process time for the Adaptive Learning Systems due to its high performance architecture.

## 7. Discussion

The study investigates the perceptions and motivations of leaners and learning providers towards the teaching and learning using adaptive learning systems by cloud computing microservice platform. The Microservices develop and enhance the adaptive learning platform for trainees and trainers. The provided study has helped the students to understand the subject, and it improved their self-efficacy. We asked the learners and teachers to use this technology to enhance their performance and quality in using ALS.

We also introduced an exciting approach, as the new trends in various areas are emerged day by day, the new architecture for various applications is evolving. There is a demand from users for interactive, rich and dynamic experience on various platforms. These demands are satisfied by the applications having high availability, scalability and easy-to-execute on cloud platform. Most of the organizations want to update their applications frequently, several times a day. Monolithic applications have the limitation to support such demands. In this paper, we discussed the Microservices architecture, which can support to achieve above requirements. The applications with this new architecture have multiple services, which can deploy independently. These services focus on a minor part of the applications. Microservices provide scalability and agility to the applications. [37]



## 8. Conclusion:

The microservices new technology needs to face the modern progressive development. The FaaS technology and its Microservice Platform is a suitable technology to enhance and improve performance and quality of the adaptive learning systems and its scalability and improves the system reliability.

In FaaS system, the functions expected to start within milliseconds in order to allow handling of individual requests. In PaaS systems, by the contrast, there is typically an application thread, which keeps running for a long period and handles multiple requests.

# References

[1] Chunxi Tan et al, "Adaptive Learning Recommendation Strategy Based on Deep-Q-Learning," *Applied Psychological Measurement*, vol. Vol. 44(4) , p. 251–266, 2020.

[2] Haoyang Li et al, "Adaptive Learning System and Its Promise on Improving Student Learning," in *10th International Conference on Computer Supported Education*, China, 2015.

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

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

[5] V. Raj, "A Framework for Migration of SOA based Applications to Microservices Architecture," *Journal of Computer Science & Technology*,, Vols. Volume 21, Number 2, 2021.

[6] Isak Shabani et al, "Design of Modern Distributed Systems based on Microservices Architecture," *International Journal of Advanced Computer Science and Applications*, Vols. Vol. 12, No. 2, 2021.

[7] Muhammad Waseem et al, "Design, Monitoring, and Testing of Microservices Systems: The Practitioners' Perspective," *Journal of Systems and Software*, 2021.

[8] V. K. Pachghare, "Microservices Architecture for Cloud Computing," *Journal of Information Technology and Sciences*, vol. 2, no. 1, 2018.

[9] N Morze et al, "Implementation of adaptive learning at higher education institutions by means of Moodle LMS," *Journal of Physics: Conference Series*, 2021.

[10] Yuliya H. Nosenko et al, "The state of the art and perspectives of using adaptive cloud-based learning systems in higher education pedagogical institutions" (the scope of Ukraine)," *Creative Commons License Attribution 4.0 International, Ukraine*, 2019.

[11] Kateryna Osadcha et al., "The Review of the Adaptive Learning Systems for the Formation of Individual Educational Trajectory , Ukraine," *Creative Commons License Attribution 4.0 International, Okaine*, 2020.

[12] Victoria Mirata et al, "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.

[13] Hassan Khosravi et al, "Development and Adoption of an Adaptive Learning System: Reflections and Lessons Learned," in *Technical Symposium on Computer Science Education Conference*, Portland, USA, 2020.

[14] Maiia Marienko et al, "Personalization of learning through adaptive technologies in the context of sustainable development of teachers' education," *E3S Web of Conferences, France*, 2020.

[15] Yanan Li et al, "A Zeroth-Order Adaptive Learning Rate Method to Reduce Cost of Hyperparameter Tuning for Deep Learning," *MDPI Journal*, 2021.

[16] A. D. S. e. al, "Reflections on Adaptive Learning Analytics: Adaptive Learning," January 2021. [Online]. Available: https://www.researchgate.net/publication/348716769.

[17] Meng-Leong HOW and Wei Loong David Hung, "Educational-Stakeholders-Independent-Evaluation-of-an-Artificial-Intelligence-Enabled-Adaptive-Learning-System-Using-Bayesian-Network-Predictive-Simulations," *MDPI Journal,China,* 2019.

[18] Peyman Akhavan et al, "Knowledge management and adaptive e-learning: Iranian Schools Case Study," in *19th European Conference on Knowledge Management ECKM*, Iran, 2018.

[19] X. W. a. B. Wong, "Bridging Knowledge Divides Utilizing Cloud Computing Learning Resources in Underfunded Schools: Investigating the Determinants," *Journal of Educational Computing,* 2018.

[20] Sucheta Kolekar et al, "Adaptive User Interface for Moodle based E-learning System using Learning Styles," in *3rd International Conference on Computer Science and Computational Intelligence*, 2018.

[21] Christoph Fröschl et al, "Learner Model in Adaptive Learning," in *Academic Network of Loc Nguyen Conference*, Vietnam, 2018..

[22] Polina M. Vanyukov et al, "Neurcomputational mechanisms of adaptive learning in social exchange," Cognitive, Affective, & Behavioral Neuroscience, 2019. [Online]. Available: https://doi.org/10.3758/s13415-019-00697-0.

[23] Chuck Dziuban, "Adaptive Learning: A Stabilizing Influence Across Disciplines and Universities," *Online Learning Journal,USA,* 2019.

[24] Oleksandr Yu. et al, "Using the students' state indices for design of adaptive learning systems," *Information Technologies and Learning Tools Journal,* vol. 68, no. 2076-8184., 2018.

[25] Shirin Mojarad et al, "Studying Adaptive Learning Efficiancy using Propensity Score Matching," in *International Conference on Learning Analytics & Knowledge*, 2018.

[26] Benjamin D. et al, "SKOPE-IT (Shareable Knowledge Objects as Portable Intelligent Tutors): overlaying natural language tutoring on an adaptive learning system for mathematics," *International Journal of STEM Education,* 2018.

[27] L. Ç. a. H. Keser, "Adaptation of interaction in web environments with educational content," *World Journal on Educational Technology,* vol. 10, no. 3, pp. 142-152, 2018.

[28] Min Liu et al, "Investigating the effect of an adaptive learning intervention on students' learning," *Association for Educational Communications and Technology,* 2017.

[29] Chun-Hui Wu et al, "An Adaptive e-Learning System for Enhancing Learning Performance: Based on Dynamic Scaffolding Theory," *EURASIA Journal of Mathematics, Science and Technology Education,* 2017.

[30] M. Rani et al, "An ontology-based adaptive personalized e-learning system, assisted by software agents on cloud storage," *Journal of Engineering Education,* 2015.

[31] Benjamin Doerr et al, "On the Runtime Analysis of Selection Hyper-Heuristics with Adaptive Learning Periods," in *Genetic and Evolutionary Computation*, Kyoto, Japan, 2018.

[32] Abdel Fatah Hegazy et al, "'An Adaptive Framework for Applying Cloud Computing In Virtual Learning Environment at Education a Case Study of "AASTMT"," in *International Conference on Communication Management and Information Technology (ICCMIT)*, Cairo, Egypt, 2015.

[33] Sucheta Kolekar et al., "Adaptive User Interface for Moodle based E-learning System using Learning Styles," in *3rd International Conference on Computer Science and Computational Intelligence*, Karnataka, India, 2018.

[34] Kinshuk, N. S. Chen, L. Cheng and S. Wai , "Evolution is not enough: Revolutionizing current learning environments to smart learning environments," *International Journal of Artificial Intelligence in Education, 26(2), 561–581*, 2016.

[35] J. Yang, H. Yu, C. Gong and Kinshuk, "Future trends of smart learning environments. E-educational research," pp. 5, 85–88, 95, 2015.

[36] R. Huang, Y. Hu and J. Yang, "Improving learner experience in the technology rich classrooms," *Kinshuk & R. Huang (Eds.), Ubiquitous Learning Environments and Technologies, Berlin* , pp. 243-258, 2015.

[37] V. K. Pachghare, "Microservices Architecture for Cloud Computing," *Journal of Information Technology and Sciences*, vol. 2, no. 1, 2016.

[38] S. Neuman, "Building Microservices," *O'Reilly Media, Inc.,* 2015.

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

[40] P. K. Sahoo, "On the design of efficient link based virtual resource management algorithm for cloud platforms," 2017.

[41] X. W. a. B. Wong, "Bridging Knowledge Divides Utilizing Cloud Computing Learning Resources in Underfunded Schools: Investigating the Determinants," *Journal of Educational Computing*, 2018.