

Impact of DevOps and Cloud Computing on Building up an E-learning Environment

Priyanka Gupta¹, Kanika Thakur², Loknath Das³, Manish Nehra⁴, Sushmita Kumari⁵,
Vandana Kumari⁶

Priyanka Gupta, Assistant Professor, School of CSE, Lovely Professional University

Kanika Thakur, School of Computer Science and Engineering, Lovely Professional University

Loknath Das, School of Computer Science and Engineering, Lovely Professional University

Manish Nehra, School of Computer Science and Engineering, Lovely Professional University

Sushmita Kumari, School of Computer Science and Engineering, Lovely Professional University

Vandana Kumari, School of Computer Science and Engineering, Lovely Professional University

-----***-----

Abstract - Education plays a vital role in a student's life. The mammoth demand for quality education created a competitive space for many Ed-tech and online learning platforms. A modern-day education should cope-up with the latest technology that the twenty-first century demands. With the thrust for digital learning material and remote learning, cloud-based platforms have become more valuable than ever. The purpose of this project is to design an E-Learning website by leveraging the power of cloud computing and demonstrating the usefulness of DevOps Methodology in the development process. Our Process of building an online learning web app platform will eliminate the manual task that needs to develop a traditional app and deploy it to the production environment by using DevOps Methodology and public cloud. It will also highlight the importance of cloud computing, and the impact it created in the education sector. This platform is cost-efficient as it is built on top of a cloud. In addition to all the above-mentioned points and benefits, the platform would consist of a login and sign-in portal, student portal, and instructor portal where the respective student and instructor can view their schedule, the instructor can upload the videos or take a live lecture, etc. The platform will be using Kubernetes for its production environment for high availability.

Key Words: Cloud Computing, DevOps, Front-end, Back-end, E-learning.

1. INTRODUCTION

Cloud Computing has evolved way beyond traditional online data storehouses. It has given us the benefit of the decentralized allocating method. It is a suitable platform that requires minimal human intervention, as it helps to incorporate digitization into the educational process.

In terms of education, it mainly revolves around bringing education from the classroom and delivering it to our homes or universities. Technology in education has come up to a new skyline making any form of education or remote education more accessible and online. [1]

These unprecedented times have shown us that digital adoption and cloud learning are here to put up a fight and challenge the traditional system of education.

Recently, India saw its fourth EdTech unicorn entry in 2021, and the country's ever-growing user base is indicating more start-ups to join in. "According to a report by IBEF, India is that the second-largest marketplace for e-learning ventures after the USA, and therefore the sector is predicted to contribute US\$ 1.96 billion by 2021 with around 9.5 million learners." [17]

The boom in the Ed-tech sectors is likely due to the ease of availing the IT infrastructure such as cloud computing. Cloud computing helps to shift the entire physical education infrastructure to the internet.

Due to such advanced and hassle-free serverless architecture EdTech companies can leverage the updated digital solutions to run fully organized, distant institutional workloads and significantly improve responsiveness, business intelligence, and an improved span for future creation – all at twice the pace of an on-premise infrastructure configuration. [2]

The proposed system is a web-based learning portal on top of the cloud. It allows a student to create an account, and upon creating an account it creates an isolated portal for the student, where the student can access all the learning resources. The system also facilitates an isolated portal/page for instructors to manage their courses. The process for developing this website is done through the DevOps lifecycle, where the primary focus is to make the Development and deployment part efficient, cost-saving, and agile.

This learning management system will be built with different DevOps tools, and all the underlying infrastructure would be present in the cloud. The particular system will highlight the importance of cloud computing and how fast and cheap it is to build an E-learning website using cloud computing.

2. Problem statement

In this fast-paced world keeping up with the educational needs and developing an online web-based application for those needs consumes an enormous chunk of time. Cloud computing helps to develop a learning platform quickly without investing in a mammoth of hardware. Our website is based on mitigating the issue of quality education needs and highlighting the importance of cloud computing and the DevOps process for building up software rapidly.

3. Theoretical side

3.1 Cloud Computing Concepts and Architecture

Cloud computing architecture can be categorized into two sections: the front end and the back end. Both front end and backend are connected through a physical network, usually over the internet. The front end part is what the client sees, whereas the back end is the abstraction of the complex system.

The front end is the client's computer, and the application is required to access the cloud. The backend has the cloud computing services like various compute resources, servers, virtual networks, and data storage.

Monitoring of incoming and outgoing traffic, aiding the system, and client demands are administered by a central server. It follows certain protocols and uses special software known as middleware. Whereas middleware allows networked computers to intercommunicate with each other. [5]

The diagram in figure 1 depicts the different layers of cloud computing architecture

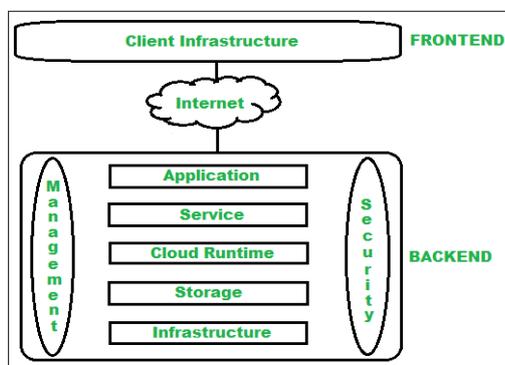


Fig-1: Cloud Computing Architecture

3.2 DevOps Methodology

DevOps is a communications theory, both within itself and across other divisions, as developers and operators need to harmonize within the organization. DevOps works regularly with ITOps practices to sustain secure and stable testing environments for it to make sense to turn to other departments such as marketing and customer service by deploying new applications. [6]

Development and Operations are critical for any business in the modern era. And ITOP's functions incorporate guaranteeing safety, compliance, and reliability. While the DevOps team is in charge of designing and delivering end-users new products. Even as ITOps supplies reliability and safety for all client needs via the network, DevOps goes hand in hand with flexibility and meticulous reckoning and communication with the implementation of the latest software. [7]

3.3 Concept of Online Education

Fast-paced developments in technology have made distance learning easy. Most terms such as online learning, open learning, web-based education, computer-mediated learning, amalgamated learning, E-learning have one thing in common. That is the ability to use a computer connected to a network. Which offers the opportunity to learn anywhere, anytime, in any cadence, with any means.

Online learning can be termed as a tool that can make the teaching and learning process more student-centered, more innovative, and even more adaptable. Online learning

Is defined as learning experiences in synchronous or asynchronous surroundings using different devices (e.g., mobile phones, laptops, tablets, etc.) with internet access. In these environments, students can be located anywhere to learn and interact with instructors and other students. [8]

4. Benefits of Cloud Computing for online education

There are numerous benefits of cloud computing when it comes to deploying an application, whereas building up any software takes a considerable effort, and it wouldn't be budget-friendly for startups or solo instructors to build a learning platform from scratch traditionally. Cloud computing solves these problems through its different services that are needed to build an e-learning application.

4.1 Connectivity

Cloud computing allows EdTech companies and academic institutes to customize and share their inventory of files, apps, and media such as online video classes and lessons with ease. It brings satisfying connectivity of education to young intellects. Cloud also influences education by bringing together distinct sorts of digital libraries of shared resources. [1]

4.2 Ease of implementation

Using Cloud Computing to develop an E-learning website a teacher or institution can adapt and publish educational content without buying hardware programs, software licenses installation, maintenance assistance, etc. Online education or building a web learning platform gets streamlined through the cloud.

4.3 Easy access and availability of resources

Cloud-based schooling also affects the supply of resources and study materials. As Cloud provides 24 x 7 availability of educational resources that improve physical and digital accessing also. A cloud-based learning system not only helps to access the resources seamlessly but also lets students see the changes dynamically. Cloud obeys the Web Content Accessibility Guidelines (WCAG) and security protocols to preserve the integrity of data. [1]

4.4 Rapid Elasticity

Cloud technology is often flexibly provisioned and terminated, in certain gears mechanically balanced quickly approaching, and active proportionate with the demand. To the clients, the capabilities existing for provisioning much of the time appear to be unlimited and can be suitable in any measure at a given time. [3]

5. Proposed System

This paper aims to provide information about the working of the e-learning website that is built on top of the cloud. It also provides the architecture and DevOps methodology / CI/CD pipeline used to build this project efficiently.

The evolutionary fads in technology have fetched quick transformations in all aspects of education. That includes the enrollment process, content development, and delivery, medium of instructions and assessment, result calculation, student-teacher exchanges, analysis, and staff development programs. The recent outburst of (COVID-19) shows the growing influence of technology on education. Multiple academic establishments across the globe leaned on the use of technologies to ensure continuous education during the lockdown. [9]

The use of E-learning platforms delivers opportunities for students to acquire new skills and structure their learning trajectory. By taking account of all these points, we leveraged the power of the cloud and DevOps method to build an integrated e-learning environment.

Utilizing cloud computing in E-learning is a terrific choice as it allows the educators to use cloud scalability, flexibility, and security to support the main paradigm of E-learning. Which is

to obtain training anywhere, at any moment, from any device. It is the root technology of the subsequent generation of network computing platforms, especially in the field of education, cloud computing is the basic environment and platform of future E-learning. It delivers secure data storage, promising internet services, and mighty computing power. [10]

The Website consists of two major parts i.e. the Lecturer portal and the Student Portal. Both the parties have to register themselves i.e. signup into the portal, upon signing up the Lecturer would get the isolated profile.

A lecturer can view courses they created, can track the revenue earned through the course, and can modify the profile.

Whereas Students will get a student profile upon creation of an account and can purchase the courses, choose different payment options for buying the courses, can modify the profile, and keep track of the courses taken.

5.1 Lecturer portal

The role hierarchy within the E-learning platform allows the instructor to only care about training: from the creation of the training process in his course to the choice of strategies and content delivery. Within his courses of competence, the instructor has full power concerning the creation of lessons that can be also organized according to the requirement of the courses. The lecturer can also add the different types of activity and resources in the form of video, audio, text, and images.

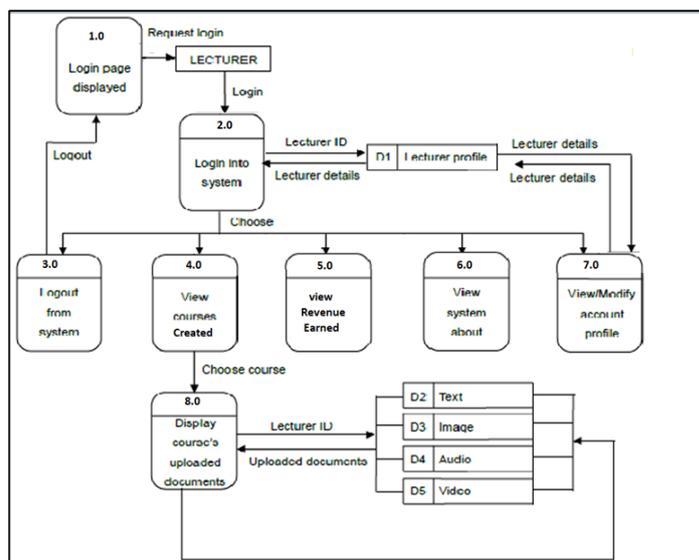


Fig -2: Lecturer Portal Data Flow

5.2 Student Portal

Eventually, at the base of the hierarchical pyramid of the Learning management system, there are users enrolled as students. It is, apparently, the role with less control: it allows students to only navigate the courses that they are enrolled in, see events in the shared calendar and messages from the lecturer, access reports of their advancement. In this application, the student is the one with less dynamic functionalities since they can only complete actions and tasks assigned by the instructor.

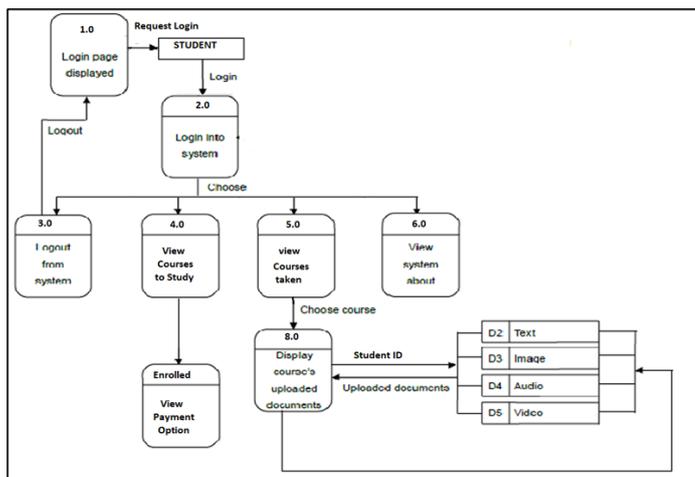


Fig -3: Student Portal Data Flow

5.3 Infrastructure

For the Infrastructure part of the Website, it uses DevOps Methodology to deploy a containerized Node.js application using Docker over AWS Kubernetes Engine and using Jenkins for continuous integration and continuous delivery.

Continuous Integration and Continuous Delivery are two of the approaches that shape DevOps principles. Mainly it includes executing development and integration workflows. As soon as developers commit their changes to the central repository, DevOps ensures that their commits are functional and ready to be deployed to production. For the automation part, it uses Jenkins.

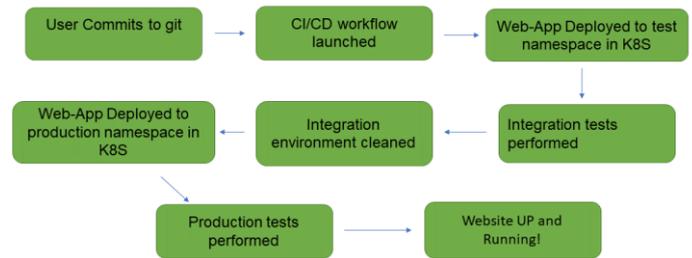


Fig -4: Workflow

As soon as the developer commits to the central GitHub repo, the Jenkins build gets triggered, and it launches a CI/CD workflow. After the build is completed the learning management website gets deployed to the test namespace in the AWS Kubernetes (EKS), and it performs the integration testing, after the successful integration test, the integration environment gets cleaned, and the learning management website gets deployed to the production namespace in Kubernetes and performs the production tests. After the successful test, the e-learning website runs efficiently leveraging the power of the cloud.

Amazon Elastic Kubernetes Service (Amazon EKS) runs the Kubernetes management infrastructure across multiple AWS Availability Zones to eliminate a single point of failure and achieve high availability. Amazon EKS is a certified Kubernetes conformant, and it utilizes existing tooling and plugins from partners and the Kubernetes community. Applications running on any traditional Kubernetes environment are thoroughly compatible and can be migrated to Amazon EKS. [11]

This E-learning website uses a highly available architecture that spans two Availability Zones, A virtual private cloud (VPC) configured with public and private subnets according to AWS best practices, to provide isolation and the best network on AWS.

In the public subnets, this learning platform uses managed NAT gateways to allow outbound internet access for its resources in the private subnets, and in one public subnet it uses, a Linux bastion host in an Auto Scaling group that allows inbound Secure Shell (SSH) access to Amazon Elastic Compute Cloud (Amazon EC2) instances in private subnet

The bastion host to access the resources is configured with the Kubernetes kubectl command-line interface that manages the Kubernetes cluster. It also spun up an Amazon EKS cluster, which provides the Kubernetes control plane. In the private subnets, a group of Kubernetes nodes is also used.

Fig -4: Contains the Detailed architecture design of the infrastructure part of an E-learning website that leverages the power of AWS Cloud.

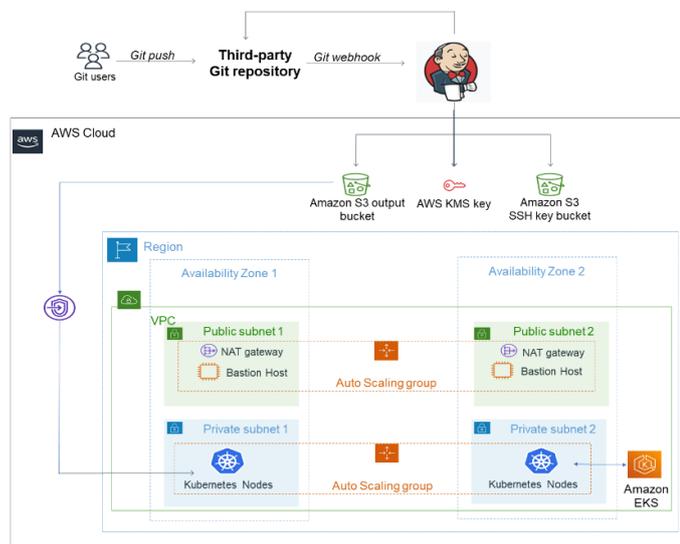


Fig - 5: Deployment Architecture

The Amazon VPC Used for this E-learning website includes public and private subnets. The first set of private subnets share the default network access control list (ACL) from the Amazon VPC, and a second, optional set of private subnets includes reliable custom network ACLs per subnet.

The Build involves the division of the Amazon VPC address space across the multiple Availability Zones, and deploys either NAT instances or NAT gateways for outbound Internet access for private resources, depending on the AWS Region. It can scale it up or down by adding or removing subnets and Availability Zones according to the needs and by adding other infrastructure components and software layers to complete the AWS environment.

6. DevOps to build an E-learning app

Traditional team structures to build software are not effective because they don't scale and often have contrasting philosophies, restricting their ability to collaborate.

As technology continues to mature, more flexibility is demanded. DevOps is a culture that gives organizations the capability to react to ever-changing and inflating market demands. When development and operations teams arrive together. By understanding each other's situations and opinions, they can construct and furnish resilient software products at fast pace.

When comparing Standard IT Ops to DevOps, it's clear to see how they vary and why DevOps is increasingly adopted by organizations worldwide. [13]

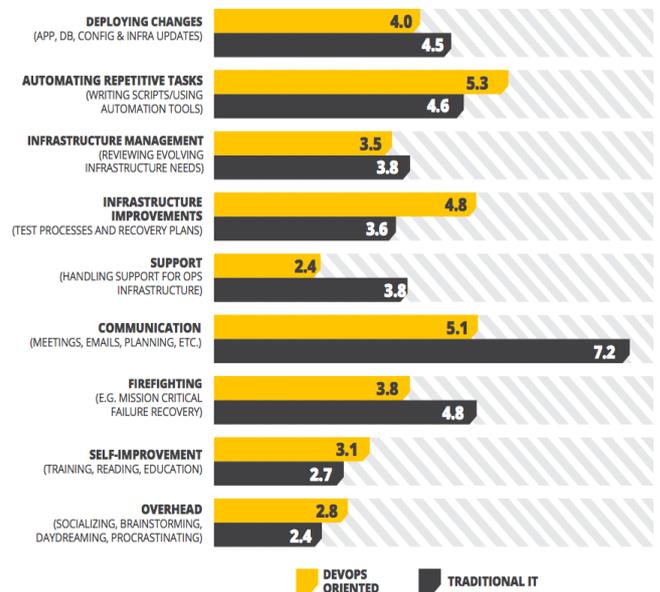


Fig – 6: DevOps Oriented Productivity [12]

DevOps teams get more accomplished and solve problems quickly. They spend more time enhancing things, shorter time patching things, recuperate from failures quickly, and release applications more than twice as fast as Traditional IT Ops. With every member of the diverse parts of IT performing together they all have the identical goal, which is to bring quality software into the market. [13]

7. Technology Used

Learning Management System requires interaction from users, and JavaScript exactly let us do that. The application we made is based on an integrated learning environment using Full-stack development and cloud computing. It is an E-learning marketplace that generates money for platform owners and Instructors.

The system is built using Nextjs, React, Nodejs, MongoDB, AWS, and Express. This website uses ReactJs to render views in web or mobile applications, it allows a developer to make changes in pre-defined components, it also shows the recent changes without refreshing the pages. Next. Js helps to load the Javascript and CSS that are needed for any given page.

Node.js is an open-source, cross-platform runtime environment. It is easily employed as a server-side proxy where it can handle a large number of simultaneous connections in a

non-blocking manner. Express contains extra libraries that are extracted as per the project's requirements ex: API, Express-JWT for a token, etc. MongoDB is an open-source document database and using it MongoDB is easy for developers to store structured or unstructured data. It uses a JSON-like format to store documents.

This E-learning platform stores all the relevant information of students and instructors in this Database. For authentication and forgotten passwords, AWS Simple Email Service (SES) is used to send the mail to the users for resetting their passwords.

It is also used for sending marketing messages, and for other transactional emails.

7.1 DevOps Tools and Cloud

The tools used for Building up an infrastructure part of the website involves, Git and GitHub where git is open-source software originally developed by Linus Torvalds. Git manages the group files for extensive and short projects. This allows the team to constantly improve their product. It is a core part of DevOps, continuous delivery pipelines, and cloud-native computing. Code for the E-learning platform is stored on the GitHub repository.

This project uses Jenkins for CI/CD. Continuous integration & continuous delivery are integral parts of DevOps, as they are used for combining numerous stages of the method. There are many CI/CD tools in the market but Jenkins is the most popular among them. This continuous integration server runs in servlet containers such as Apache Tomcat.

Jenkins fosters continuous integration and continuous delivery in software projects by automating parts associated with building, testing, and deployment. Jenkins automates the software builds continuously and lets the developers know about the errors at a premature phase. [14]

For the cloud infrastructure part this E-Learning website uses AWS, Amazon Web Services is an exhaustive, evolving cloud computing platform provided by Amazon that contains a mixture of infrastructure as a service, platform as a service, and software as a service offering. AWS services can proffer an organization tools such as compute power, database storage, and content delivery services. This Project uses S3, EC2, EKS, VPC, and KMS services of AWS. [15]

The website uses Kubernetes as its hosting platform, it is an open-source container orchestration medium that is used extensively for production environment for building up a microservice architecture-based application. In the end, it reduces the operational burden. It can run in a data center, or a public, private, or hybrid cloud, but for the sake of this E-learning website it is running on top of the public cloud. [16]

Kubernetes smoothens the container duties. It lessens activities like canary deployment, rolling updates, AB deployments, horizontal auto-scaling, etc. It plays a major role in streamlining the development process of this learning portal and testing as well as deploying pipelines in the DevOps Managed Services. This E-learning platform intensively uses Kubernetes as a service i.e. AWS EKS.

8. Conclusion

This E-learning Platform is built on top of the cloud and to build this platform DevOps methodology has been used for efficient development. In this paper, the main idea was to implement the E-learning platform by highlighting the Importance of Cloud and DevOps. This method made it easy for developing high availability E-learning websites, as compared to the traditional method of building software by using this method the E-learning platform achieved automation and availability by being cost-effective.

REFERENCES

- [1] Mittal, A. (2022, February 21). *Cloud computing: Impact on EdTech*. Magic EdTech. Retrieved March 28, 2022, from <https://www.magicedtech.com/blogs/cloud-computing-impact-on-edtech/#:~:text=The%20impact%20of%20Cloud%20Technology,of%20education%20to%20young%20minds.>
- [2] Venkatram, V. (2022, January 24). *Unlocking the value of cloud computing in Education*. DATAQUEST. Retrieved March 28, 2022, from <https://www.dqindia.com/%E2%80%A8unlocking-the-value-of-cloud-computing-in-education/>
- [3] Kaur, Tarandeep & Kuliya, Muhammed & Sarki, Abdulkadir & Sharma, Dr & Suleiman, Muhammad. (2021). A Review of Application of Cloud Computing In Education. 1. 46-55.
- [4] National Institute of Standards and Technology - Computer Security Resource Center - www.csrc.nist.gov
- [5] Jadeja, Y., & Modi, K. (2012). Cloud computing - concepts, architecture and challenges. *2012 International Conference on Computing, Electronics and Electrical Technologies (ICCEET)*. <https://doi.org/10.1109/icceet.2012.6203873>
- [6] Forsgren, N., and Humble, J., 2015, "DevOps: Profiles in ITSM Performance and Contributing Factors", SSRN Electronic Journal.
- [7] Sabharwal, N., Rathore, R., & Agrawal, U. (2021). Introduction to agile and DevOps. *Hands-On Guide to AgileOps*, 29–40. https://doi.org/10.1007/978-1-4842-7505-4_3
- [8] Dhawan, S. (2020). Online learning: A panacea in the time of covid-19 crisis. *Journal of Educational Technology Systems*, 49(1), 5–22. <https://doi.org/10.1177/0047239520934018>
- [9] Onyema, Edeh & Eucheria, Nwafor & Uchenna, Ezeanya & Nkiruka, Patricia & Eucheria, Ani. (2020). Impact of E-

- learning Platforms on Students' Interest and Academic Achievement in Data Structure Course. 1. 1-16.
- [10] Team, |B. Q. (2021, January 28). *Admin, teacher and student: Roles and functionalities in LMS platforms*. Quiddis. Retrieved March 29, 2022, from <https://www.quiddis.com/en/admin-teacher-and-student-roles-and-functionalities-in-lms-platforms/>
- [11] Quickstart. (1988). *Quickstart*. Amazon. Retrieved March 29, 2022, from <https://aws.amazon.com/quickstart/architecture/amazon-eks/>
- [12] Logan, M. J. (2014, February 16). *Fresh stats comparing traditional it and devops oriented productivity*. DevOps.com. Retrieved March 29, 2022, from <https://devops.com/fresh-stats-comparing-traditional-it-and-devops-oriented-productivity/>
- [13] Morgan, J. (n.d.). *DevOps vs. traditional it* Jamie Morgan. RSS. Retrieved March 29, 2022, from <https://www.missioncloud.com/blog/devops-vs-traditional-it>
- [14] *What is Jenkins? how & why to use it?* LambdaTest. (2022, March 25). Retrieved March 29, 2022, from <https://www.lambdatest.com/blog/what-is-jenkins/>
- [15] Gillis, A. S. (2020, April 7). *What is AWS (Amazon Web Services) and how does it work?* SearchAWS. Retrieved March 29, 2022, from <https://www.techtarget.com/searchaws/definition/Amazon-Web-Services>
- [16] *What is devops? what is the importance of kubernetes in devops?* NEX Softsys. (n.d.). Retrieved March 29, 2022, from <https://www.nexsoftsys.com/articles/importance-of-kubernetes-in-devops.html>
- [17] Education industry analysis. IBEF. (n.d.). Retrieved March 30, 2022, from <https://www.ibef.org/industry/education-presentation#:~:text=It%20has%2012%20institutes%20and,around%201.6%20users%20in%202016>.