# A Framework of Software as a Service Using a Crowdsourcing Approach: A Case Study of Smart Classroom

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**Introduction/Importance of Study:** Crowdsourcing can be effectively utilized to identify factors and develop modules by creating a platform where individuals contribute their ideas and suggestions. This research investigates the application of crowdsourcing-based cloud resources managed on a global scale, bringing together diverse skills to handle workloads on cloud platforms. Despite inherent challenges such as quality control due to the varied locations of contractors, and communication issues including language barriers, differing time zones, and security concerns, crowdsourcing provides a robust framework. It enables software developers to access a vast talent pool and deliver services more quickly and efficiently.
**Novelty Statement:** The crowdsourcing framework leverages the collective wisdom of diverse individuals to solve problems and generate ideas. In a smart classroom setting, this approach can be applied by setting clear objectives, engaging students through appropriate platforms, fostering collaboration, collecting data via surveys or discussions, analyzing results, and using insights to enhance learning experiences. By leveraging students' contributions, educators can enhance collaboration, creativity, and engagement in the classroom, ultimately enriching the learning process for all participants.
**Materials and Methods:** This research is divided into three phases:

- Identification Phase: Challenges are identified through a systematic literature review (SLR).
- Implementation Phase: Identified factors are shortlisted to design a framework.
- Validation Phase: The framework is validated using a smart classroom case study.

**Results and Discussion:** Our findings indicate that smart classrooms provide an opportunity to investigate how students adopt technology and innovation. Survey results show that both teachers and students believe smart classrooms enhance their knowledge and perceived ease of use, demonstrating the benefits of this educational approach.
**Concluding Remarks:** By exploring the case of the smart classroom, this research challenges existing pedagogical methods and introduces innovative ways to engage students through new technology acceptance perspectives. This study highlights the potential of crowdsourcing in creating more effective and interactive learning environments.

**Keywords:** Cloud Resources; Crowdsourcing; Smart Education; Pedagogy and IT.

**Introduction:**

The rise of information technology over the past two decades has significantly impacted society. The acceleration of information exchange has benefited individuals' daily lives and expanded companies' resources beyond their immediate knowledge and capabilities. Before the widespread availability of the World Wide Web, companies operated with limited resources, relying on their internal innovations to gain first-mover advantages. These business models were based on closed innovations and structured processes, often leading to inflexibility and slowness. To overcome these limitations, many companies began rethinking their business models, opening their innovation processes to external stakeholders such as suppliers, competitors, and customers.

One prominent method of open innovation, initially labeled by Jeff Howe in 2006 as crowdsourcing, involves including a diverse group of people in processes of competition and cooperation. Over the years, this approach has flourished, resulting in numerous crowdsourcing platforms. Crowdsourcing has become an essential form of open innovation, with platform providers offering various resources. However, customers often face multiple possibilities and barriers, which can relate to the specific crowdsourcing project or internal company structures and processes.

Cloud computing offers the rental of servers, storage, networks, software technologies, tools, and applications as needed over the Internet, rather than permanent possession. These services provide new methods, flexible resources, and economies of scale via the Internet ("the cloud"). Many firms reduce IT infrastructure expenditures by using cloud computing. It is a model for developing and deploying IT services through the Internet, hiding the particulars of IT infrastructure, administration, and control from customers. There are four categories of cloud computing:

- **Infrastructure as a Service (IaaS)**: Provides hardware such as processors, storage, graphics, and networks as a service (e.g., Amazon's EC2 and S3).
- **Platform as a Service (PaaS)**: Offers a programming platform and mechanisms like Java, Python, .Net, MySQL, and APIs as a service, including databases, development tools, and web servers.
- **Software as a Service (SaaS)**: Provides applications as a service, such as on-demand software, virtual desktops, communication tools, and email clients. This research focuses on SaaS, where customers use services through cloud computing without needing to buy the software, only renting it when required.

This research aims to provide an overview of crowdsourcing platforms' business practices and common challenges in a cloud environment. It explores the advantages of using crowdsourcing for Software as a Service in cloud computing resources. Surveys were conducted to gather cloud software developers' requirements, and data analysis provided diverse results. A case study evaluated the use of crowdsourcing and SaaS services. Despite the benefits of using crowdsourcing in cloud-based software development, several challenges are noted in existing literature, including the lack of efficient quality control mechanisms, intellectual property protection, limitations in domain expertise, coordination and communication challenges, scalability limitations, and cultural and language barriers.

The crowdsourcing framework leverages the collective intelligence and contributions of a diverse group to solve problems, generate ideas, or complete tasks. In a smart classroom context, this framework can enhance collaboration, creativity, and learning outcomes among students. Implementing a crowdsourcing framework in a smart classroom allows educators to harness the collective intelligence of students, fostering collaboration, innovation, and engagement. This approach enriches learning experiences and empowers students to take ownership of their education and contribute meaningfully to the learning community.

**Research Questions:**

- **RQ1**: How can we design and develop a framework for SaaS using the crowdsourcing approach in cloud-based software development?
- **RQ1.1**: How can we identify the factors and modules using crowdsourcing with the help of primary and secondary sources (SLR & survey)?
- **RQ1.2**: How can we examine the framework through a case study?

**Research Objectives:**

The primary objective of this research is:

- To conduct a comprehensive review of the literature through a systematic literature review (SLR) and study the factors and challenges in cloud-based software development.
- To design a framework by conducting a survey and analyzing the identified factors.
- To present related theoretical methodologies, frameworks, practical methods, and guidelines for future research.
- To examine the effectiveness of crowdsourcing by providing directions and expertise through a cloud-based case study.

**Novelty Statement:**

The proposed framework is validated through use cases of cloud development, leveraging the collective wisdom of diverse individuals to solve problems or generate ideas. In a smart classroom, this crowdsourcing approach can be applied by setting clear objectives, engaging students through appropriate platforms, fostering collaboration, collecting data through surveys or discussions, analyzing the results, and using insights to improve learning experiences.

Crowdsourcing parameters in smart classrooms with cloud applications involve creating platforms for idea generation, engaging students through various channels, facilitating content creation and sharing, implementing feedback mechanisms, optimizing resource allocation, building community, ensuring data security, and integrating with learning management systems (LMS). These parameters aim to enhance educational experiences by fostering collaboration, innovation, and student engagement while leveraging the capabilities of cloud technology.

A case study of a smart classroom, where students used various services over the Internet via crowdsourcing and cloud computing, was conducted to examine students' behavior regarding technology acceptance. This case study demonstrates how the proposed framework can be applied in real-world educational settings, highlighting the benefits of integrating crowdsourcing and cloud computing to improve learning outcomes. By encouraging active participation and collaboration, smart classrooms can create a dynamic and engaging learning environment that harnesses the collective intelligence of students.

**Literature Review:**

The term "crowdsourcing" was introduced by Jeff Howe and Mark Robinson in 2005. They described how businesses began leveraging the Internet to "outsource work to the crowd," utilizing this model to obtain goods, services, ideas, and financial contributions from a rapidly growing group of internet users. Crowdsourcing merges the concepts of "crowd" and "outsourcing" but differs from traditional outsourcing by being more inclusive and public. The advantages of crowdsourcing include reduced costs, increased speed, improved quality, enhanced flexibility, and scalability. Key factors defining crowdsourcing include the involvement of a crowd, a specific objective for the work, clear rewards for participants, a known crowd sourcer, transparent compensation, an online process, an open call, and internet-based practices. Cloud computing provides computing services—such as servers, storage, databases, networking, software, analytics, and intelligence—via the Internet ("the cloud"). This model enhances efficiency and flexibility while minimizing IT infrastructure costs. It represents a shift in the provision and utilization of IT services, where the details of infrastructure management are

handled by service providers. Microsoft's Azure Services Platform is a significant example of cloud computing's expansive approach. Cloud computing addresses challenges related to capacity, bandwidth, storage, security, complexity, consistency, and trade-offs by incorporating advancements in virtualization, parallel and distributed systems, utility computing, and software services.

Cloud services include the "Compute Cloud" for code integration and server farms, and the "Storage Cloud" for virtual storage services. Cloud-based advancements involve integrated development environments, code repositories, software modeling, documentation tools, and application management. This model has become a leading approach in IT infrastructure, offering flexible, scalable, and cost-effective solutions in recent years. Crowdsourcing serves as a framework that harnesses collective capacity and fosters innovation while reducing costs and time associated with problem-solving. It significantly increases the volume of valuable ideas from diverse sources and can provide solutions that might not be achievable by individuals alone. For instance, the Privacy Flag initiative leverages the "wisdom of the crowd" to enhance privacy and data control through tools like browser add-ons and smartphone applications. In this research, a systematic literature review was conducted. Table 1 details the search terms used, specifically "Software as a Service AND Cloud AND Crowdsourcing" with the AND operator. Retrieval dates for conference and journal papers are as follows: IEEE (12.7.2021), Springer (14.7.2021), ACM (14.7.2021), Elsevier (14.7.2021), and Taylor & Francis (14.7.2021). The search process involved selecting or rejecting papers based on abstract, title, general, and detailed study criteria. Inclusion criteria focused on articles containing the specified keywords, published by 2021, and sourced from Springer, ACM, IEEE, and Taylor & Francis journals. Exclusion criteria removed articles not published in English, those from books or news sources, and duplicate entries. Selected articles were categorized based on Cloud/Crowdsourcing Services, Platforms, Techniques, Infrastructures, Models, and Systems.

Different Cloud/Crowdsourcing Services are listed in Table 2, including Amazon Web Services, context-aware services, Sensor-Cloud services, and various applications. Platforms discussed in Table 3 include pig sub-platforms, Cloud-based platforms, multi-agent platforms, and more. Techniques covered in Table 4 range from novel methods to multi-tenancy techniques and Docker technology. The study explains the theoretical framework of ontology in human-computer cloud environments, emphasizing the integration of human capabilities and knowledge into cloud systems to handle dynamic and unpredictable scenarios. Cloud infrastructure is critical for web services, with robustness testing being essential for maintaining service continuity. Issues arising from infrastructure failures are exemplified by potential impacts on global businesses, such as banking. Models reviewed in Table 5 include China's cloud computing advancements, the P-SaaS model, and various others, reflecting China's leadership in cloud computing due to its large market and government initiatives. Systems discussed in Table 6 include Crowdcloud, TaaS systems, and various other models, highlighting the application of crowdsourcing in cloud computing. The paper proposes a framework for crowd-cloud, addressing notable features and limitations, with a focus on improving its theoretical and practical aspects. Further research is needed to address ongoing issues and enhance customer privacy in crowd-cloud systems. Table 7 summarizes various factors of SaaS and crowdsourcing, such as costs, speed, quality, and scalability. Cloud computing provides a cost-effective solution for global software development, addressing challenges related to communication and coordination in geographically dispersed environments. Factors of SaaS & crowdsourcing are further detailed in Table 8, emphasizing crowdsourcing techniques and their application in maintaining high quality and addressing challenges in a geographically and culturally diverse crowd. This framework focuses on specific challenges and limitations, ensuring effective solutions and highlighting cloud-based software development models.

**Table 1**: Search Terms and Results

| Terms | Operator | IEEE | Springer | ACM | Elsevier | Taylor & Francis |
|---|---|---|---|---|---|---|
| Software as a Service AND Cloud AND Crowdsourcing | AND | Conference 11<br>Journal 06 | Conference 11<br>Journal 1 | Conference 567<br>Journal 237 | Journal 141 | Journal 49 |
| **Selected** | | 6 | 2 C | 16 C 9 J | 6 | 2 |

**Table 2:** Cloud/Crowdsourcing Services

| Sr. No | Cloud/Crowdsourcing Services | References |
|---|---|---|
| 1. | Amazon Web Services | [1][2][3] |
| 2. | context-aware services | [4] |
| 3. | Sensor-Cloud services | [5][6] |
| 4. | Activity-aa Service | [3] |
| 5. | ITO (information technology outsourcing services) | [7] |
| 6. | RoSA App | [8] |
| 7. | Cloud Navi | [9] |

**Table 3:** Platforms

| Sr. No | Platform | References |
|---|---|---|
| 1. | Pig sub platform | [10] |
| 2. | Cloud-based platform | [11] |
| 3. | Multi-agent platform | [10] |
| 4. | Daas as crowdsourcing platform | [12] |
| 5. | edX platform | [13] |
| 6. | Competition-based crowdsourcing platform | [14] |
| 7. | Smart City platform | [14][15] |
| 8. | Crowdsourcing-based video distribution | [2] |

**Table 4:** Techniques

| Sr. No | Techniques | References |
|---|---|---|
| 1. | Novel techniques | [16] |
| 2. | Multi-tenancy technique | [17] |
| 3. | XML, HML 5 | [17] |
| 4. | Docker Technology | [12] |
| 5. | xSE-ACAS [10] (encrypt and access road accident information) | [17] |

**Table 5**: Infrastructures

| Sr. No | Infrastructures | References |
|---|---|---|
| 1. | Open Stack cloud | [18] |

**Table 6:** Infrastructures

| Sr. No | Model | References |
|---|---|---|
| 1. | China's cloud computing | [11] |
| 2. | P-SaaS model | [19] |
| 3. | Multi-tenant model | [17] |
| 4. | VM model | [17] |
| 5. | LDA (Latent Dirichlet Allocation) | [20] |
| 6. | Weather forecasting model | [21] |
| 7. | UTAUT theory model | [22] |

**Table 7:** Systems

| Sr. No | Systems | References |
|---|---|---|

| | | |
|---|---|---|
| 1. | Crowd cloud | [23] |
| 2. | TaaS system | [24] |
| 3. | AVM system | [17] |
| 4. | Smart Traffic | [25][26] |
| 5. | RoSa-Cloud | [8] |
| 6. | Spee-Navi | [27] |
| 7. | CMS system | [17] |
| 8. | Cyber-Physical and Cloud Systems | [28][29] |
| 9. | Park Scan | [30] |

**Table 8:** Factors of SAAS & Crowdsourcing

| Sr. No | Factors | References |
|---|---|---|
| 1. | Costs | [31][32] |
| 2. | Speed | [33] |
| 3. | Quality | [34][35] |
| 4. | Elasticity | [18] |
| 5. | Scalability | [36][31][37][38] |
| 6. | Open call | [18] |

Several limitations have been identified in existing studies related to crowdsourcing and cloud-based software development. Key challenges include ensuring consistency and quality of contributions, navigating ownership and rights issues, managing large volumes of submissions, and addressing skill gaps among contributors. Additional concerns involve fair compensation for labor and ideas, vulnerability to malicious contributions on open platforms, and potential project stalls due to waning crowd interest. Despite the increasing demand for cloud-based software development, current methods often struggle with scalability, cost, and innovation. Traditional software development can be time-consuming and costly, failing to keep up with rapidly evolving user needs. While crowdsourcing demonstrates collective intelligence and creativity, it lacks a structured framework for integration with cloud-based development. Therefore, there is a need for a framework that leverages crowdsourcing principles to enable collaborative, scalable, and cost-effective software development in the cloud. This framework would facilitate the rapid delivery of high-quality services that adapt to changing user demands.

**Material and Methods:**

The primary aim of this research is to evaluate the feasibility of crowdsourcing as a design and development method for the software industry. The research methodology, illustrated in Figure 1, encompasses the following steps:

- **Analyze and Explore**: Assess existing software development techniques and methods that are suitable for crowdsourcing.
- **Assess Current Platforms**: Identify the key properties and factors of current crowdsourcing platforms for future improvement.
- **Design Framework**: Develop a framework based on SaaS cloud software development principles.
- **Evaluate Framework**: Apply the framework through a case study of a cloud-based smart education system.
- **Validate Framework**: Test the framework using generated test cases.
- **Address Issues**: Identify and resolve persistent issues related to compensation and inconsistencies to enhance future implementations.

Advancements in scientific knowledge, societal progress, and the shift to a sharing economy have transformed smart city residents into clients of smart data services. A crowdsourcing-based video distribution platform can improve video quality at minimal cost by utilizing agent-based video recreation. Docker technology provides flexibility and portability,

making the platform scalable across various problems and fields. Crowdsourcing in software development for online education is viable with diverse stakeholders and a licensing model that promotes crowd contributions. Cloud technology is increasingly replacing in-house infrastructure in educational institutions, offering economic benefits and delivering efficient, accessible resources for both teachers and students.

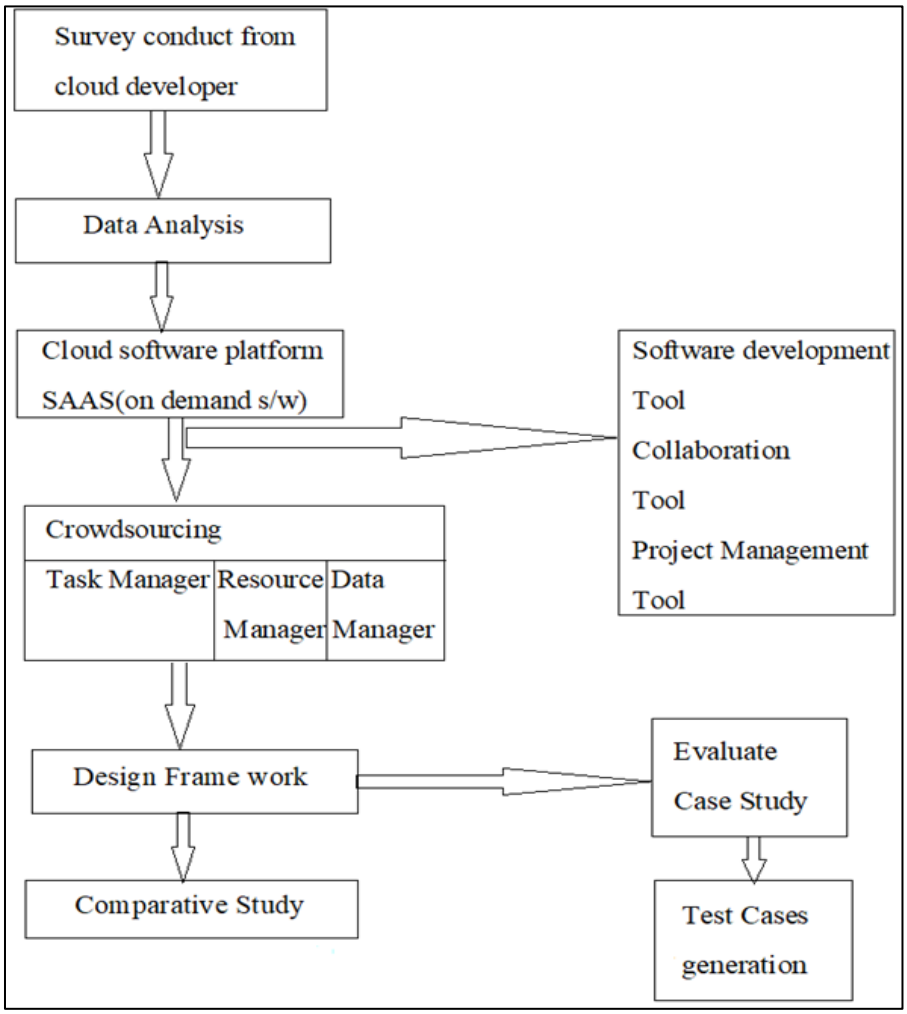


**Figure 1**: Methodology flow to design SAAS framework

A survey conducted among cloud developers aimed to evaluate the current services of Software as a Service (SaaS) in cloud-based software development using a crowdsourcing approach. Stratified sampling was employed to target a diverse population, gathering insights from employees across various departments about the effectiveness of this approach. Both quantitative and qualitative questionnaires were utilized for data collection, with qualitative data helping to identify and address employee concerns while enhancing services. The questionnaire, comprising 15 valid questions—both closed and open-ended—was distributed both online and offline to professionals from software houses like Sadaat Murshad, companies such as AWT and AH Group of Companies, the Pakistan Poverty Alleviation Fund (PPAF), educational institutions including NUST, and other institutions across Punjab.

The research employed a mixed-method approach, with 67% of the analysis being quantitative, based on closed-ended questions, and 33% qualitative, based on open-ended questions. Targeting IT professionals from software houses, companies, and educational institutions, the survey revealed a demographic distribution of 24% female and 76% male respondents. Key findings highlighted various issues faced by professionals, including internet speed problems, security and privacy concerns, limited application ranges, and integration

challenges. While some professionals were satisfied with the services, others expressed concerns about their adequacy for high-quality tasks. Customer satisfaction varied, with 28% indicating use only under certain conditions, 44% agreeing to regular use, 24% disagreeing, and 4% commenting on overseas experiences. Knowledge of crowdsourcing varied: 68% had moderate knowledge, 16% had little knowledge, 8% were experts, and 8% had high knowledge. Regarding service requests through crowdsourcing, 40% sought service requests, 32% ideation, and 28% content creation. Crowdsourcing was considered an innovative tool by 44% of professionals, with 12% strongly agreeing, 12% disagreeing, and 32% remaining neutral. Advances in crowdsourcing over the past decade were noted by 36% as high activity, 28% as a new paradigm, 32% as medium activity, and 4% as low presence. User-generated content was seen as a way to nurture authenticity and transparency by 12%, enhance understanding of the target audience by 56%, improve SEO value by 16%, and enable cost-effective marketing by 16%. The impact of crowdsourcing on new product and service development, advertising, promotion, sales, and market research varied. Regarding information externalities and consumer privacy, 64% agreed that crowdsourcing activities affect organizations, 12% disagreed, and 24% noted an impact only under specific conditions. Initial interest in crowdsourcing for cloud computing was driven by the need to collect global expert opinions (48%), reuse group work (20%), save time and money (16%), or a combination of these factors (16%). Industries expected to benefit most from cloud computing included automotive (28%), education (16%), financial (12%), real estate (20%), insurance (4%), healthcare (16%), and all of the above (4%). If a SaaS provider goes out of business, 48% of respondents anticipated a pause in operations, 28% expected disaster, and 24% foresaw limited time to salvage data. Customizability of SaaS features was noted by 60% who valued feature toggling, 24% who appreciated UI customization, and 16% who valued logo and domain customization. For effective software deployment in cloud computing, 40% favored private cloud, 16% preferred hybrid cloud, 28% supported public cloud, and 16% chose community cloud. Deployment methods included manual standards for remote access (36%), scripts (20%), configuration management tools (28%), or schedulers (16%). Commonly mentioned issues included internet speed, data security, application range, high resource usage, integration, cost, and performance.

In the context of advancing technology and educational methods, the shift from traditional knowledge learning to active and constructive learning is increasingly recognized. The integration of information technology into education, exemplified by smart classrooms, transforms teaching methods and enhances student engagement. Smart classrooms leverage cloud, terminal, and network technologies to replace conventional tools like blackboards, offering a more interactive and effective learning environment. These classrooms facilitate academic analyses, resource sharing, and personalized learning experiences that align with students' interests and needs. The framework for SaaS development using a crowdsourcing approach in smart classrooms incorporates these technological advancements to support collaborative, scalable, and cost-effective educational solutions. Figure 2 illustrates the proposed framework, developed using primary and secondary sources (both survey data and factor analysis), and validated through a case study demonstrating how students can access various services via the internet, leveraging crowdsourcing and cloud computing to enhance their learning experiences.

**Crowdsourcing Platform**: A platform designed to engage a diverse crowd in the development process.

- **User Contribution System**: Enables users to contribute code, ideas, feedback, and resources.
- **Incentive Mechanism**: Rewards contributors through monetary compensation, recognition, or other incentives.

**Cloud Infrastructure**: The underlying technology supporting the deployment, scaling, and management of the SaaS.

- **Scalability**: Ensures the system can accommodate increasing numbers of users and data.
- **Security**: Safeguards data integrity and user privacy.

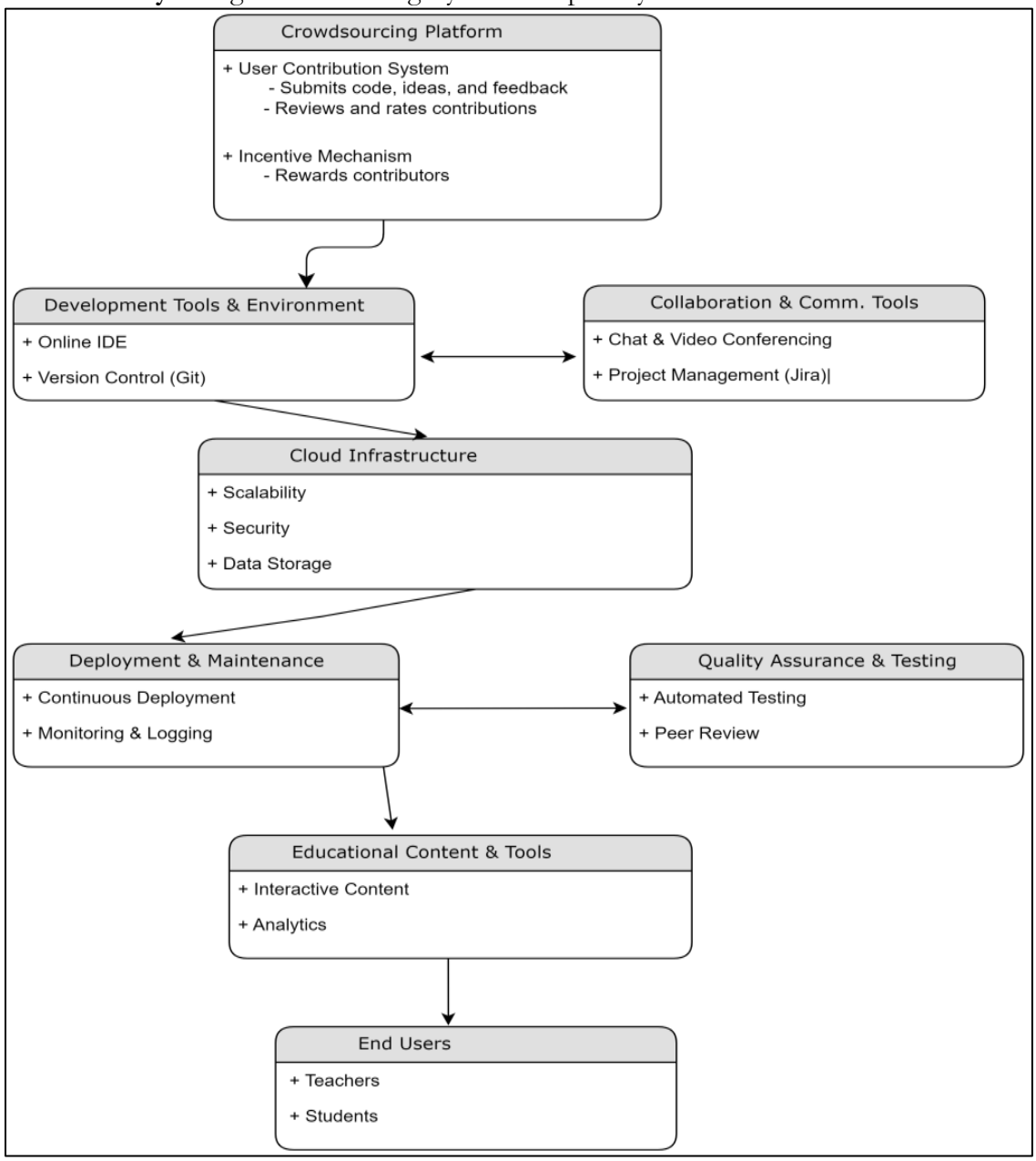


**Figure 2:** Proposed framework for the use of crowdsourcing services to active learning environment

**Data Storage**: Efficiently manages and stores large volumes of data.

**Development Tools and Environment**: Provides essential tools for the crowd to develop, test, and deploy software.

- **Integrated Development Environment (IDE)**: Online IDEs accessible through the cloud.
- **Version Control**: Tools like Git for managing code contributions.

**Collaboration and Communication Tools**: Facilitates effective communication among developers and stakeholders.

- **Chat and Video Conferencing**: Tools such as Slack or Zoom for real-time communication.
- **Project Management**: Platforms like Jira or Trello for tracking progress and tasks.

**Quality Assurance and Testing**: Ensures the software meets quality standards and is free from bugs.

- **Automated Testing**: Tools for continuous integration and automated testing.
- **Peer Review**: Code review processes involving multiple contributors.

**Deployment and Maintenance**: Processes for deploying the software and ensuring its ongoing operation.

- **Continuous Deployment**: Automated processes for deploying updates.
- **Monitoring and Logging**: Tools for tracking performance and identifying issues.

**User Feedback and Iteration**: Mechanisms for collecting user feedback and iterating on the software.

- **Feedback Loops**: Regular collection of feedback from end-users.
- **Agile Development**: Iterative development cycles based on user feedback.

**Educational Content and Tools**: Specific features tailored for the smart classroom environment.

- **Interactive Content**: Tools for creating and managing interactive learning materials.
- **Analytics**: Tools for tracking student performance and engagement.

**Case Study: How Crowdsourcing Affects the Smart Education System to Promote an Active Learning Environment:**

In the smart classroom, teachers adopt a blended learning approach to enhance student engagement. The internet provides access to a vast array of topics for every subject, which both teachers and students can utilize at any time. This access is crucial to the learning process. While textbooks offer limited syllabi, students often seek additional knowledge on current topics. Traditional teaching methods, where teachers dictate notes and students write them, can split attention between listening and writing, detracting from understanding the lecture. In contrast, smart classrooms utilize PowerPoint slides, images, audio, and videos, which students can more easily comprehend. Teachers can share these resources digitally, allowing students to focus on comprehension rather than note-taking.

For students who miss classes, retrieving missed lectures can be challenging, and teachers cannot feasibly repeat them. Students typically rely on notes and photocopies, which may not be as comprehensible. In smart classrooms, lectures are recorded and made available online, allowing students to review missed material at their convenience. This method addresses difficulties in understanding complex topics through text alone. Simulation lab tools in smart classrooms help students grasp these concepts through active participation.

Traditional classrooms may lead to disengagement, with students feeling sleepy or distracted. Smart classrooms create a more engaging environment through interactive activities like online tests and quizzes, which support self-assessment and enhance understanding. These resources help students build a strong foundation and perform well in exams.

Smart classrooms also host weekly guest lectures, providing students with opportunities to interact with experts and researchers. These sessions offer up-to-date information beyond textbook content and allow students to discuss current issues and research. This interaction improves communication skills and broadens students' knowledge. Online experts are also available for career counseling, helping students make informed career choices. Educational institutions now utilize cloud-based software instead of traditional installations, supporting various functions including career counseling and seminars.

A survey conducted at F.G. Quaid-e-Azam Degree College Rawalpindi and Comsats University Islamabad involved 24 college students and 33 university students (20 males and 13 females). The online survey collected 47 responses, achieving a 70% response rate. The data suggests that an active learning environment is essential for enhancing creativity and mental development. Multimedia teaching methods and smart classroom services—such as online subject specialists, online researchers, online seminars, cloud-based software, online career counseling, shared resources, and self-assessment—are highly effective.

The smart classroom strategy, initiated in 2021 by the Higher Education Commission of Pakistan with World Bank support, aims to expand the Pakistan Education and Research Network (PERN) and related services. Data collected from students using a structured survey was analyzed to test the hypothesis that designing and developing a Software as a Service (SaaS) framework through crowdsourcing will improve smart classroom solutions. This approach is expected to leverage the collective intelligence of developers, educators, and stakeholders, leading to more innovative, scalable, and user-centered smart classroom strategies. Refer to Appendix 3 for additional details on the smart classroom strategy and related initiatives.

**Sub-Hypotheses and Justifications:**

**Crowdsourcing Will Increase Innovation and Feature Variety**:

**Justification**: By involving a wide range of contributors with diverse backgrounds and expertise, the development process will benefit from a broader spectrum of ideas and solutions. This diversity can lead to more innovative features tailored to the varying needs of smart classrooms.

**Cloud-Based Infrastructure Will Provide Scalability and Reliability**:

**Justification**: Utilizing cloud infrastructure ensures that the SaaS solution can scale to accommodate a growing number of users and data. Cloud services also offer robust reliability and uptime, essential for educational environments.

**A Well-Designed User Contribution System Will Enhance Engagement and Quality of Contributions**:

**Justification**: An intuitive and rewarding contribution system will encourage active participation from developers and educators. By providing clear incentives and recognition, the quality and quantity of contributions will improve.

**Integrated Development Tools and Environments Will Streamline the Development Process**:

**Justification**: Providing contributors with powerful development tools, such as online IDEs and version control systems, will streamline the coding, testing, and deployment processes. This will reduce barriers to entry and increase productivity.

**Effective Collaboration and Communication Tools Will Improve Project Management and Coordination**:

**Justification**: Real-time communication platforms and project management tools will facilitate better coordination among contributors, leading to more efficient progress tracking and issue resolution.

**Automated Quality Assurance and Peer Review Will Ensure High Standards**:

**Justification**: Implementing automated testing and peer review processes will help maintain high quality and reliability of the software, ensuring that only well-tested and peer-reviewed code is deployed.

**Continuous Deployment and Monitoring will Enhance the System's Adaptability and Responsiveness**:

**Justification**: Continuous deployment pipelines will enable rapid updates and improvements, while monitoring tools will ensure the system remains responsive and can quickly address any issues that arise.

**User Feedback Loops Will Drive Iterative Development and Continuous Improvement**:

**Justification**: Regularly collecting and analyzing feedback from end-users (teachers and students) will guide iterative development cycles, ensuring that the SaaS solution evolves to better meet the needs of smart classrooms.

**Educational Content and Analytics Tools Will Support Personalized Learning and Performance Tracking**:

**Justification**: Integrating tools for creating interactive educational content and tracking student performance will support personalized learning experiences and provide valuable insights for educators.

**Results and Discussion:**

A survey conducted at F.G. Quaid-e-Azam Degree College Rawalpindi and Comsats University Islamabad assessed the impact of smart classrooms. The objective was to explore how an advanced learning environment—integrating technology, digital resources, and innovative teaching methods—can enhance the educational experience. The use of interactive tools and multimedia content in smart classrooms has notably increased student participation and interest. By focusing on critical thinking, problem-solving, and digital literacy, smart classrooms are effectively preparing students for the digital age.

The survey data, analyzed through descriptive statistics, provides insights into the demographic distribution of respondents. Of the 47 participants, 26 were aged 18 to 25, 12 were between 25 and 30 years old, and 9 were aged 30 to 50. This distribution highlights the diverse age range of individuals engaging with smart classroom technologies.

**Table 9:** Age of Respondents

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| **Valid** | 18- 25 | 26 | 55.3 | 55.3 | 55.3 |
| | 25-30 | 12 | 25.5 | 25.5 | 25.5 |
| | 30-50 | 9 | 19.2 | 19.2 | 100.0 |
| | **Total** | 47 | 100.0 | 100.0 | |

As data is collected from college and university students, so 20 were undergraduate students, 18 were graduates and 9 were teachers, 47 respondents as shown below table

**Table 10:** Participants

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| **Undergraduate** | 20 | 42.5 | 42.5 | 75.0 |
| **Graduates** | 18 | 38.2 | 38.2 | 38.2 |
| **Teachers** | 09 | 19.2 | 19.2 | 100.0 |
| **Total** | 47 | 100.0 | 100.0 | |

**Survey Conducted by Students on Smart Classrooms:**

The Higher Education Commission (HEC) of Islamabad, in collaboration with the World Bank under the Higher Education Development Pakistan project, aims to expand the Pakistan Education and Research Network (PERN) and its associated services to select colleges across the country. This initiative, detailed in Appendix 3, includes the provision of PERN connectivity infrastructure, such as routers, firewalls, and switches, as well as Wi-Fi access, video conferencing facilities, and additional resources like Microsoft licenses, Turnitin accounts, and Coursera access. Initially, the HEC has identified 31 colleges affiliated with the University of the Punjab to benefit from these services, with F.G. Quaid-e-Azam Degree College Chaklala III Rawalpindi among the recipients.

This survey evaluates how modern technology, particularly smart classrooms, can enhance the education system. By integrating innovative technology, both students and teachers can benefit, gaining insights into how such advancements address current educational challenges in Pakistan. Data collection involved distributing a questionnaire to students and teachers at Comsats University Islamabad and F.G. Quaid-e-Azam Degree College Chaklala III Rawalpindi.

The questionnaire, accessible through the web link in Appendix 2, contained 10 questions, both closed and open-ended, aimed at assessing the effectiveness of smart classrooms and identifying areas for improvement. Survey results showed that 20% of respondents were female and 80% were male. While most participants expressed satisfaction with the smart classrooms, some noted challenges. Students reported high levels of satisfaction, with 20% of teachers highlighting improvements in digital literacy, 30% in teamwork, 10% in critical thinking, 20% in providing a genuine learning experience, and 10% in skill development.

Regarding the perception of smart classrooms as a waste of time, 70% disagreed, and 30% were neutral. Most participants (90%) agreed that the smart classroom design met students' learning needs, and 70% believed that teachers could accurately assess student behavior and capabilities. All respondents agreed that smart classrooms benefit distance learners, although 20% raised concerns about technology's negative impacts, such as misinformation, over-dependence, time wastage, and health issues. The survey also emphasized the value of crowdsourcing platforms like GitHub, AWS Marketplace, and cloud providers such as AWS and Azure for enhancing smart classroom development. Crowdsourcing can gather diverse expertise and innovative solutions, while cloud platforms offer tools for performance monitoring, debugging, and security. Engaging with crowds through various channels can provide unique insights and foster innovation.

**Recommendations for Future Enhancements in Smart Classrooms:**

**Enhanced Crowdsourcing Platforms:**

- Develop dedicated platforms for crowdsourcing ideas from students, teachers, and stakeholders, either as specialized websites or integrated into existing LMS.
- Promote these platforms through social media, email campaigns, and school networks to attract diverse participants.

**Improved Cloud Resource Management:**

- Ensure cloud infrastructure is scalable to handle varying workloads and user demands.
- Facilitate global collaboration with tools that support seamless integration and communication among participants.

**Advanced Software Development Practices:**

- Implement robust quality control mechanisms, including peer reviews, automated testing, and continuous integration.
- Provide effective communication tools for real-time collaboration, translation services, and scheduling across different time zones.

**Security and Data Privacy:**

- Implement strong security protocols, including encryption, secure access controls, and regular audits.
- Develop comprehensive data privacy policies to protect personal information.

**Integration with Learning Management Systems (LMS):**

- Ensure seamless integration of crowdsourcing platforms and cloud tools with existing LMS.
- Facilitate content creation, sharing, and feedback within the LMS to enhance collaboration.

**Student and Teacher Engagement:**

- Provide interactive tools that encourage collaboration among students and between students and teachers.
- Conduct regular training sessions for familiarization with new technologies and crowdsourcing methods.

**Data-Driven Insights:**

- Collect and analyze data through surveys, discussions, and usage analytics to understand student behavior and technology acceptance.
- Use insights to identify areas for improvement and enhance the learning experience.

**Innovation and Continuous Improvement:**

- Foster a culture of innovation by encouraging experimentation with new ideas and technologies.
- Establish a continuous feedback loop for regular review and implementation of suggestions.

**Resource Optimization:**

- Optimize resource allocation to use computing power, storage, and other resources efficiently.
- Explore cost-effective solutions for cloud tools to ensure accessibility for all institutions.

**Community Building:**

- Build a collaborative community through events, forums, and projects.
- Recognize and reward contributions to motivate continued participation and engagement.

**Conclusion:**

Crowdsourcing enables organizations to leverage external knowledge, fostering success. Cloud-based software crowdsourcing represents a cost-effective approach to enhancing software development by integrating high-speed software and advanced network technology. Utilizing extensive cloud resources, including computing power and software databases, accommodates a large community of programmers. Historically, the Internet has facilitated various functions, from communication and content provision to software deployment platforms.

This research highlights the application of crowdsourcing in software development through cloud computing. By managing cloud resources globally, this approach gathers diverse skills and distributes workloads efficiently. The study demonstrates how crowdsourcing can enhance smart classroom technologies in Pakistan and evaluates the benefits and limitations of integrating crowdsourcing with existing software development practices.

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**Appendix link:**
https://docs.google.com/document/d/1tQOpS4Ys0LwV3HYI_RCHG9pZLoMrsaPR/edit?usp=sharing&ouid=114794836543689594030&rtpof=true&sd=true