Cloud-based learning service platform for multilingual smart class

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ABSTRACT

The spread of cloud computing is accelerating universities to seek a better educational approach for capitalizing on its capabilities. With the practice of cloud computing in Saudi Arabia universities, instructors are yet unable to interact with the students face-to-face due to the gender separation practice. It becomes worse in a multilingual environment as the students are less fluent in the first language formally practiced in the university. With the current best practice, the students are able to utilize one app to translate the presentation slides and another app to translate the instructor's speech. The student prefers to comprehend the learning materials, although it delays the process of teaching. Therefore, there is a need to integrate current practices. A prototype of a smart class based on cloud computing is developed to ease the use of a mobile device. This project is evaluated by utilizing both direct and indirect assessment spanning across three academic semesters.

1. Introduction

In a traditional learning system, the instructor and his students are offline in one class with a lot of limitations. An online learning system improves the legacy learning system by enabling instructors to upload their learning materials on the internet, and therefore students download these materials in relatively flexible time and place. The online learning system is the heart of distance learning, which delivers one of the most significant contents and applications on the web. Therefore, it has been a hot topic in research and industry, especially due to the dynamic changing of the educational environment.

Saudi Arabian universities have a unique learning environment. The lectures have to be conducted in English, even though most of the students are not native in English. In fact, some of the students are not fluent in English. On the other hand, most of the instructors are the expatriates who are fluent in English, although they are not native in English, and some of them are not speaking the local language. In the university, some students have difficulty in understanding either the presentation slides or the instructor's explanation or both. One of the students with the same gender as his instructor used his camera-based language translator app to understand the text in the slides during the lecture, while other students with a different gender are listening in a separate room. This is because the students have problems with their English reading skills. Although it may delay the process of teaching and learning, the student demands a comprehensive understanding of the learning materials.

On another occasion, during the lecture, a student was trying to communicate with the instructor regarding the submission of his project. Since this was considered as an important communication, neither the student nor the instructor expects a misunderstanding due to the language barrier. Hence, the students used their voice-based translation app to translate his voice to English and the instructor's voice to his language. It happens quite often in the university since some students have problems in their English listening and speaking skills, although they satisfy the minimum requirements of reading and writing skills. However, this activity also delays the process of learning since all required apps are not integrated. In addition, the students in a different location might have difficulty to follow and join the conversation.

In terms of the learning environment, the university delivers distance learning for several courses. There are synchronous and asynchronous distance learning systems in Saudi Arabia universities. The university only provides synchronous distance learning, where the lecture is delivered in real-time. Synchronous distance

learning has two types. The first type is a real-time interactive virtual classroom. In this type, the students are able to participate in the lectures from anywhere using a specialized multimedia communication system. It plays an important role in distance learning, where instructors and students are situated in different rooms, and the class is taken synchronously as coined by Alenazy (2017).

The second type is a unique distant learning setup prevalent in Saudi Arabian universities, where female students are located in one location, and their male instructor is in another location communicating through a teleconference application. This is due to the local wisdom of the land with regard to gender-separation practices. Integrating technologies into such a classroom is able to enhance the experience of both instructors and students. This is because the instructor is able to interact with local and remote students intensively, and at the same time, the students are able to provide effective feedback to their instructor (Suo et al., 2009). The integration of technology is also beneficial to traditional face-to-face classrooms to enhance students' learning experience.

Despite the educational technology implemented in a classroom at Saudi Arabia universities, several students are facing an issue where their instructor is unable to grasp the students' faces, gestures, and visual feedback. The situation becomes worse when several students are not fluent in English, and the instructor could not speak the students' first language, although the instructor's live communication is non-trivial for attaining the focus and engagement of the students. The instructor needs to communicate with students online and instantaneously, for example, to give students oral quizzes and take attendance. Moreover, they need to get benefit from a mobile device because a lot of researchers emphasize that mobile devices play an important role in learning, instead of arguing with their students for not playing with their mobile devices (Hazaea and Alzubi, 2016).

Using technology in education is not novel in the last few decades. Advances in computer and other hardware technologies have made it possible to embed educational technology in the classroom (Uzun et al., 2015). Nowadays, mobile technology spreads all over the world due to the variety of devices, such as smartphones, wearable computing devices, tablets, and laptops. The spread of mobile devices is encouraging universities to innovate educational approaches by exploiting the strength and opportunity of the devices. One such approach is mobile learning (m-learning) (DeWitte, 2010). Through m-learning, most learning materials can be reached by any constituents, such as students without any time and place constraints (Al-Emran et al., 2016). M-learning originates in electronic learning (e-learning), which exploits electronic technology, such as tape, disc, or the Internet (Alhassan, 2016). However, these technologies have fallen short of their potential to improve the educational system in Saudi Arabia.

To address these problems, there is a need to examine the comprehensive use of mobile devices in the current system used by Saudi Arabian universities. A prototype of a smart and integrated class based on cloud and service computing is required to see the performance of the students and their perception towards it.

2. Related works

The concept of technology augmented classrooms is becoming increasingly popular due to the proliferation of mobile computing and the availability of high-speed internet connections. Several earlier projects worked on improving the learning experience of the traditional classroom using the latest technologies. One of the early efforts in providing technology-mediated learning experience is the Classtalk project (Dufresne et al., 1996). The Classtalk system consists of a number of student palm-top computers networked to a central server controlled by the instructor. The instructor can assign group tasks to the students and get students' feedback through the system. Unfortunately, the system lacks flexibility due to very specific hardware requirements and no support for wireless devices. Despite the technological limitations, Classtalk is an inspirational project that demonstrates the benefits of technology in improving the learning experience of the students. ActiveClass (Ratto et al., 2003), a more advanced system, enabled the use of wireless technology for in-class participation, where the students can give feedback on the class using their own wireless devices. However, the system only allows question and answer-type interaction, and it lacks support for smart devices to participate in the class.

In an effort to enhance the interaction within the class, the Interactive Workspace (Johanson et al., 2002) project allows networked mobile devices and integrated large displays for shared presentation of learning contents. As with the case of the ActiveClass system, the Interactive Workspace project has a very limited set of functionalities to enhance classroom teaching. The Classroom 2000 project (Abowd, 1999) and the Smart Classroom project features capturing of live classroom experiences for later access. The Ambient Intelligent Classroom project (Margetis et al., 2011) developed an augmented school desk with a connected multi-touch screen that supports the presentation of the learning materials and two-way communication between the learner and the instructor. The focus of all these projects is basically on augmenting the learning experience of a single classroom and has little support for students participating from a remote location.

In order to address the growing trend of distance learning, the Smart Classroom project (Shi et al., 2003) supports remote students' interaction and communication. However, it lacks support for smartphones and other mobile devices, which has become popular in recent years. The InterReality Portal (Pena-Rios et al., 2012) and the pervasive

mobile learning model (Vinu et al., 2011) propose the integration of various embedded devices, mobile devices, and web-based technologies to provide a rich learning experience to the remote learners. However, these systems suffer in terms of scalability, cross-platform compatibility, and flexibility.

In the light of recent technological advancements and the increasing popularity of teaching methodologies beyond the boundary of a classroom, a smart class needs to be built on a scalable and flexible platform supporting a wide range of smartphones and other mobile devices. Cloud-based infrastructure is particularly promising in this regard (Senyo et al., 2018).

El-Mhouti et al. (2018) have successfully demonstrated the use of cloud technologies in e-learning applications. Similar efforts were made by Dahdouh et al. (2017) and Kabiri and Wannous (2017). However, these systems are lacking explicit support for learners and instructors using different languages. The requirement to support multiple languages is vital in a multi-cultural environment, as demonstrated by Mustika et al. (2013) and Burns (2013).

To date, the integrated approach to combine several learning apps and language tool apps in one application interface is one of the main research gaps in e-learning research. Switching between one app to another app requires a significant amount of time that may delay the teaching-learning process. Accordingly, switching between a camera-based translation app for understanding the presentation slides and voice-based translation app for communicating to the instructor is time-consuming. There are some kinds of literature that proposed multilingual communication, which depends on specific skills such as listening, speaking, and reading. Our previous work provides the calculation technique of language certification scores in listening, speaking, writing, and reading to suggest the appropriate service (Bramantoro et al., 2015).

Another project improves this technique by conducting an intercultural experiment to evaluate the fluency and accuracy of multilingual communication with the help of computerized tools (Pituxcoosuvarn and Ishida, 2017). A huge collection of language resources has been serviced within a single infrastructure for various domains, such as agricultural resources (Murakami et al., 2012a). However, all these techniques are not intended for a learning environment that has specific requirements based on students' and instructor satisfaction.

3. Research methodology

The main objective of this research is to develop a platform that is based on cloud and services computing to support the learning process in the smart class. A software prototype model is the expected outcome. The analysis, design, and implementation documents are the most useful results of the research. Thus, the outcome is a generalized software platform and additional functionalities of the system, as explained in the following research methodology.

- To provide atomic and composite services of e-learning to satisfy instructors' and students' requirements.

  o Composite language services: Multilingual chat service, multilingual group discussion service, multilingual question and answer service, image-based translation service.
  o Atomic learning services: Translation service, specialized dictionary services discussion service, slides presentation service, question, and answer service.

- To accommodate some students who are not confident in their English to participate more actively during the lecture, especially for the distant learning of female students in an Islamic university.
- To provide consistent learning records information about learners and learning experiences at the university.
- To provide apps that can accommodate the transparency of student's activity during the lecture, smartboard for group discussion, multilingual question and answer between students and instructor.

  o Slide service-based app: This app can import the slides and show the currently explained slides; the students can add comments in their first language, and the instructor can add their comments in English. Each of them can read the comments in their own native languages.
  o Smartboard service-based app: This app wrapped the existing smartboard in each university as a service and connected with instructor and students' mobile devices. It has some characteristics as follows:

    ▪ One class divided into several groups of students to discuss particular topics during the lecture.
    ▪ Each group activity is shown to the instructor desktop app so that the instructor can see the participation of each group member.
    ▪ Some diagrams are provided in this app to improve the discussion process.

  o Question and answer service-based app: This app provides a better communication of questions and answers during the lecture. Students who are not brave enough to ask a question can use this app in real-time. Moreover, Students with less English capability can improve his questions by using the translation service in this app with a specialized dictionary specific to the topic given in the lecture.

- To improve the learning process between instructors and students who has varied English

skills by creating a specialized dictionary for the technical lecture terms. The dictionary contains up to a thousand words, and we combine the dictionary with translators as well as other student dictionaries.

- To integrate the existing learning system with mobile devices owned by most students.
- To bridge the language barrier amongst non-local language-speaking instructors and less English capability students.

4. Platform design

The platform is designed based on the combination of services computing and cloud computing. In services computing, encapsulating anything as a service and utilizing a workflow to combine these services in smart class is a promising solution. In cloud computing, all learning materials are stored in the cloud that enables the openness, scalability, and performance of the system. In detail, the proposed platform consists of four layers: Cloud Infrastructure, Atomic Learning Service, Composite Learning Service, and Customized Multilingual Learning layers.

Cloud Infrastructure layer shares learning resources on the Internet to fulfill user requests based on cloud computing. The infrastructure uses the latest everything as a service (XaaS) technology. The Cloud Infrastructure consists of Learning Core Node and Learning Service Node in the Cloud, as initially adopted in an international project of the Language Grid in a study by Ishida et al. (2018). Learning Core Node includes learning service management service, search, composition, and access control, while Learning Service Node provides learning resources as web services. All communications in this platform are based on simple object access protocol (SOAP), and all services are described in web services description language (WSDL) (Paik et al., 2017).

In the Atomic Service layer, various learning resources are provided as web services with a standardized interface. Users can add and customize new learning resources. Several existing applications in the university are wrapped as atomic service. This wrapper is the key to realize XaaS since basically it can wrap anything as a service and combine with any component level applications, as previously developed in the study by Bramantoro et al. (2010).

In the Composite Service layer, learning resources and applications can be combined seamlessly by using business process workflow. Various new learning services are available through this combination. Users can add their workflow suitable for their purpose. For example, by combining existing teleconference service and slide service with the user's specialized dictionary service, users can make a comment on the slides shown in teleconference based on the dictionaries specialized for the discussed topics.

In the Apps layer, apps are developed by utilizing the available services, both composite and atomic services, to provide various functions for supporting smart class. The apps are distributed amongst instructors and students to support the learning process in class or distant class. It is important to note that the apps are not only used by the students with low language skills, but also by the students with much better language skills to improve the collaboration and participation amongst students.

Bramantoro et al. (2012) method is utilized to measure the quality of each service. Hence, it enables the dynamic composition of services. As illustrated in Fig. 1, the first service of voice translation for two languages delivers a low service enthalpy. The learning platform enables the second composition as a dynamic composition of other services that replace it to provide a better service enthalpy. The new composition includes a voice to text service for the same language, text translation services between two languages, and text two speech feature for the same language provided by voice translation service.
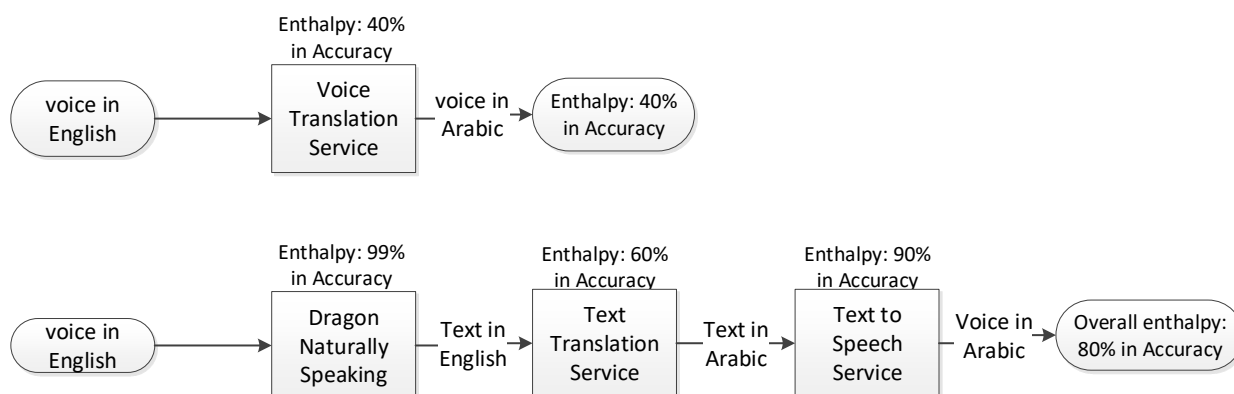

Fig. 1: Dynamic composition of services for a learning platform

We aim to build a prototype system called the Learning Service Platform. This prototype is applied in Saudi Arabia universities, where the existing smart class has already been implemented. Existing smart class systems such as touch-sensitive smart board, Blackboard learning management system, and Cisco teleconference; are in this platform. Connected in the cloud infrastructure of the platform, the smart classes, and multiple modules in them improve the learning process in the university.

All devices and software modules run on the Learning Service Platform to communicate and collaborate with one another. xAPI (Bakharia et al., 2016), an open-source API considered as the latest and mature standard for learning technology, is considered as the best practice for any learning system developments. It enables data collection on student and instructors' experiences. xAPI is basically a web service providing read and write access for clients on experiential data. xAPI is chosen because it is aligned with the service platform that we plan to build, in addition to the trend that this API replaces all existing standards in learning technology in the future. We believe that the service technology in xAPI is reliable enough to be combined with other services on our platform.

The main technique to implement this project is XaaS., especially with everything in the cloud nowadays, and everything can be easier to be wrapped as a service. Additional functionality and non-functionality are possible to be added to the existing platform by using Web service technology (Murakami et al., 2012b). Hence, all services from the existing application and data, and all new services are in one single platform, i.e., Learning Service Platform, in order to choreograph and orchestrate into a better learning process in the university.

5. Platform utilization

In this project, we expect to develop a cloud-based learning service platform for a smart class and a working prototype of a range of learning services and apps. The cloud-based learning service platform is used to deliver a wide range of apps and services for the smart class. The platform is accessible anytime, anywhere, and from any connected device.

By using the synchronized slide show service, the students are able to view the slides that are being presented by the instructor synchronously in their mobile devices during the class. This service is integrated with the translation service for the on-the-fly translation of the content. This service utilizes the best practice translation app and wraps it as a service. One of the best practices for this service is a camera-based translation app to translate the slide.

An example of an app that composes all services in one platform is illustrated in Fig. 2. In this app, slide and voice translation services are composed in one app interface to enable a better interaction not only between instructor and students but also amongst students. In addition, to speed up the process of commenting on the slides, a handwriting feature is enabled in each of the slides to provide the instructor with an answer to this comment. Although it is possible to wrap the text recognition application as a service in the platform, this feature remains the future development.

The question and answer service (multilingual) enables live communication between the instructor and the students through their mobile devices. The on-the-fly translation feature allows students to interact with the instructor in their native language. One of the best practices for this service is a voice-based translation app to have multilingual two-ways communication between instructor and student.
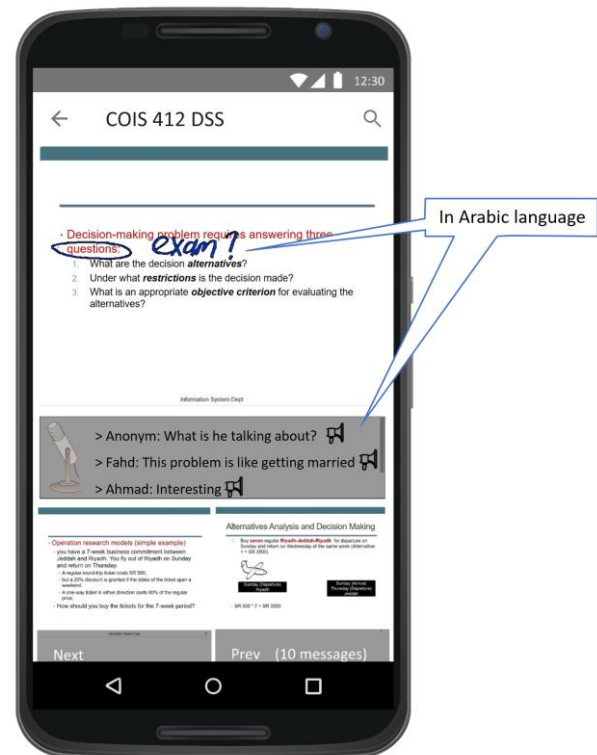

Fig. 2: An app that integrates slide, translation, smartboard, and question-answer services

The online group activity service (multilingual) hosts in-class group activities where students are assigned to have group activities such as case studies and decision-making problems. Accordingly, the instructor is able to monitor the contribution of each group member online. This is enabled due to the fact that the service is integrated with the translation and dictionary services for multilingual communication.

By using the annotation services (multilingual), the students are able to annotate the slides or any other learning materials on their mobile devices, in multiple languages (e.g., English and Arabic) and share their notes with other students. This service is integrated with translation and dictionary services to facilitate a better understanding of the learning materials.

By using tests, quizzes service, instructors are able to conduct online and offline tests and quizzes, evaluate students' performance, and view the results. By using group discussion service, students are able to form groups and participate in group discussions, both online and offline. By using a shared smart board service, the instructor is able to write and draw on the smartboard. The content of the smart board can be displayed on the students' mobile devices. Students are able to insert any annotations using the annotation service.

Within domain-specific specialized dictionary service, every subject domain has a set of words with specific meaning for specific concepts related to that

domain. This dictionary service contains domain-specific words and seamless integration with the translation service and all other multilingual services to support the accurate translation of the learning content. Students and instructors are allowed to add words and enhance the dictionary content. The translation service is utilized to provide two-way translations of lecture contents, slides, group discussions, or any other learning content used in the smart class. Lastly, all services that are related to translation are equipped with the image searching service. Hence, when a specific word is translated by translation service, the related images are provided from the image searching service to enhance the understanding of specific words for the students.

The outcome of the research is useful for any educational or training institutes to enhance the learning experience of the learners, especially in the university where the research outcome is officially implemented, and the learning process is objectively assessed. Traditional educational institutes with gender separation benefit from this research as this research allows more effective and efficient teaching-learning methods when the instructor and the students are from different genders. Distant learning or e-learning educational institute is able to readily utilize the results of this research to augment their current teaching methodologies.

In this research, we develop a cloud-based learning service platform for a smart class and a working prototype of a range of learning services and apps. The cloud-based learning service platform is used to deliver a wide range of apps and services for the smart class. The platform is accessible anytime, anywhere, and from any connected device.

In general, the product of this research is unique for educational or training institutes in Saudi Arabia due to its characteristic of the language barrier between instructors and students as well as a distant environment between instructors and students with a different gender.

6. Evaluation

This project utilizes quantitative research modified based on the standardization in Saudi Arabia universities. It focuses on an intercultural activity in university classes. The survey measures students' intentions and attitudes regarding the use of the learning management system and its tools in one class. We work with our classes in both male and female sections. The female section is required to see how this platform benefits distant learning between male instructors and female students.

To evaluate the controlling variable, the experiments are conducted in three semesters involving the same instructor teaching one subject each semester. In the first semester, there is no implementation of our platform. In the second and third semesters, the platform is utilized by the students and the instructor for the same course. Three semesters are chosen to improve the maturity of the platform. Hence, the instructor is accustomed

to utilizing the platform. It also quantitatively represents how much the students perceived their usefulness and, at the same time, acknowledge the efficiency of the learning process in a particular environment.

To determine the impact of our platform to the students, we use direct and indirect assessments based on the student outcomes as normally conducted in Saudi Arabia universities. Direct assessment of student outcomes is achieved through quizzes, exams, projects, presentations, and homework equipped with the use of our platform in mobile devices. Direct assessment is conducted in English, but the students use the platform in their mobile to ease the understanding. Indirect assessment starts with gathering data using the surveys and feedback. Both direct and indirect assessments are collected at the end of the semester from male and female sections. The female section assessment includes the lecture conducted with the teleconference.

There are ten student outcomes based on the international accreditation that are evaluated in the university as follows (Shafi et al., 2019):

a) An accomplishment to employ the know-how of mathematical and computational techniques suitable for the departmental outcomes and to the field of study
b) An accomplishment to assess a source of difficulty as well to satisfy the need for computation
c) An accomplishment to have a plan, application, and assessment for any organization, procedures, libraries, and software that is based on digital devices
d) An accomplishment to work in a group with a specific task
e) A comprehension of the computer-related profession, ethics, law, protection, and environment
f) An accomplishment to present a successful communication in various crowds
g) An accomplishment to locally and globally assess the effect of computational system on people and companies
h) An awareness of the requirement in pursuing the career improvement
i) An accomplishment to utilize state-of-the-art technologies, capabilities, and instrumentations required for computer-related system
j) A comprehension of atmosphere processes that enable the information systems acquisition and management

However, only three of them are chosen to be evaluated in the course used in this research: (d), (h) and (j), due to limited time available. The average result of direct assessment for these three student outcomes within three semesters is illustrated with a polar diagram in Fig. 3.

It can be inferred from the result that in the second where the learning service platform was

firstly introduced, there is no significant improvement for student outcomes in general. The reason might be due to the difficulty of getting accustomed to the platform by the instructor. However, in the third semester, there is a huge increase in all student outcomes. It is argued that the

third semester is the maturity phase of the platform. In fact, the teaching process between students and the instructor becomes more enjoyable but with full responsibility. Moreover, the platform is approved to be available during the exam to understand the questions better.
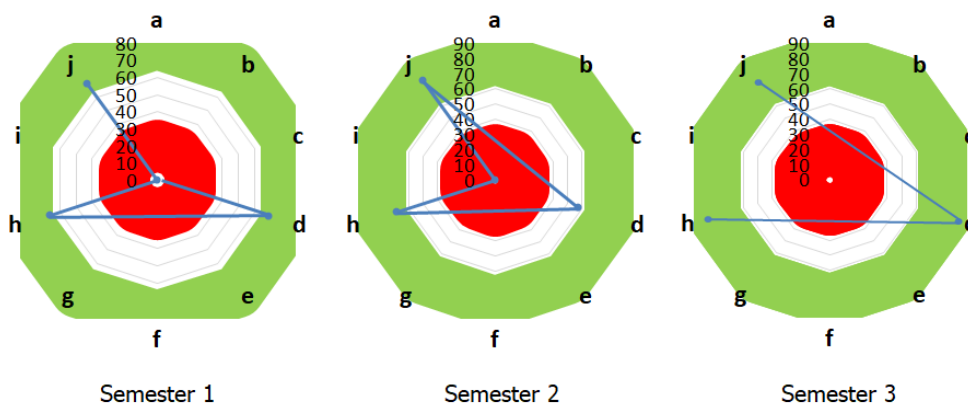

Fig. 3: Direct assessment of student outcomes

The result of indirect assessment for these three student outcomes within three semesters is illustrated with a polar diagram in Fig. 4. Similar to direct assessment, there is no implementation of our platform in the first semester. In the second and third semesters, the platform is utilized by the

students and the instructor for the same course. At the end of each semester, the students are provided independence to express their satisfaction values of each student outcomes for each outcome as feedback.
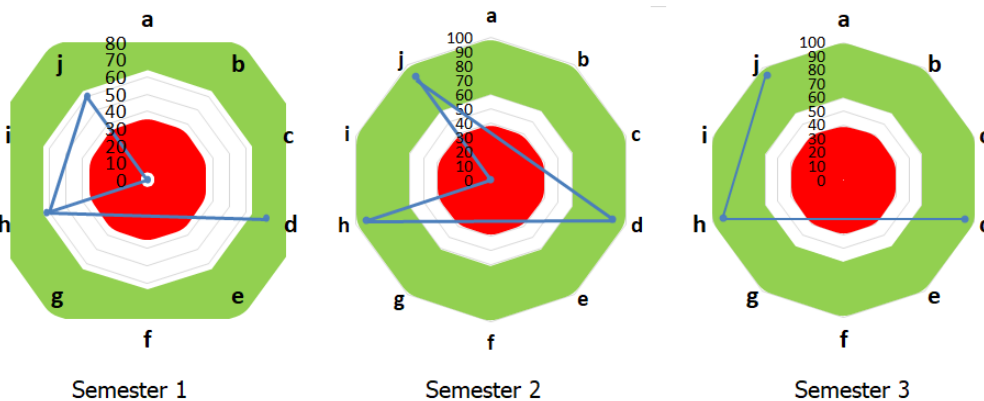

Fig. 4: Indirect assessment of student outcomes

It is interesting to note that the students show high satisfaction in using the learning service platform, although this trend is not linear to the result of direct assessment, which is based on the student's final score. It can be inferred that the apprehension of the learning materials provided by the platform is much important than the results. However, the last semester score is evidence of significant improvement compared to the two previous semesters.

7. Conclusion

The era of services and cloud computing has influenced the educational environment. This project benefits this computing paradigm and implements it as a learning service platform. Various existing and new apps, mostly related to language technology, are composed in one platform to ease the teaching-

learning process. There are three main apps that have been developed in this research: slide service-based, Smartboard service-based, and question and answer service-based apps. These three apps are composed of various atomic services, such as translation service, specialized dictionary services discussion service, slides presentation service, question, and answer service. Based on the performance evaluation of the students within three semesters, it is found that this platform benefits the students by enabling them to understand the learning materials interactively, although it is not always linear to their score.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abowd GD (1999). Classroom 2000: An experiment with the instrumentation of a living educational environment. IBM Systems Journal, 38(4): 508-530.
https://doi.org/10.1147/sj.384.0508

Al-Emran M, Elsherif HM, and Shaalan K (2016). Investigating attitudes towards the use of mobile learning in higher education. Computers in Human Behavior, 56: 93-102.
https://doi.org/10.1016/j.chb.2015.11.033

Alenazy WMG (2017). Interactivity oriented system architecture for the 21st century classroom: the new smart classroom. Ph.D. Dissertation, University of Technology, Sydney, Australia.

Alhassan R (2016). Mobile learning as a method of ubiquitous learning: Students' attitudes, readiness, and possible barriers to implementation in higher education. Journal of Education and Learning, 5(1): 176-189.
https://doi.org/10.5539/jel.v5n1p176

Bakharia A, Kitto K, Pardo A, Gašević D, and Dawson S (2016). Recipe for success: Lessons learnt from using xAPI within the connected learning analytics toolkit. In the 6th International Conference on Learning Analytics and Knowledge, Association for Computing Machinery, Edinburgh, UK: 378-382.
https://doi.org/10.1145/2883851.2883882

Bramantoro A, Hassine AB, Matsubara S, and Ishida T (2015). Multilevel analysis for agent-based service composition. Journal of Web Engineering, 14(1 and 2): 63-79.

Bramantoro A, Kamada T, Tanaka M, Murakami Y, and Zettsu K (2012). Towards service atomization for analyzing information. In the 19th International Conference on Web Services, IEEE, Honolulu, USA: 676-677.
https://doi.org/10.1109/ICWS.2012.46

Bramantoro A, Schäfer U, and Ishida T (2010). Towards an integrated architecture for composite language services and multiple linguistic processing components. In the International Conference on Language Resources and Evaluation, Valletta, Malta: 3506-3511.

Burns R (2013). Assessment and instruction in multilingual classrooms. In: Gathercole VCM (Ed.), Issues in the assessment of bilinguals: 162-185. Multilingual Matters, Bristol, UK.
https://doi.org/10.21832/9781783090105-009
PMid:23136081

Dahdouh K, Dakak A, and Oughdir L (2017). Integration of the cloud environment in e-learning systems. Transactions on Machine Learning and Artificial Intelligence, 5(4): 55-65.
https://doi.org/10.14738/tmlai.54.2973

DeWitte CM (2010). Integrating cell phones into the secondary Montessori classroom. Walden University, Minneapolis, USA.

Dufresne RJ, Gerace WJ, Leonard WJ, Mestre JP, and Wenk L (1996). Classtalk: A classroom communication system for active learning. Journal of Computing in Higher Education, 7(2): 3-47.
https://doi.org/10.1007/BF02948592

El-Mhouti A, Erradi M, and Nasseh A (2018). Application of cloud computing in e-learning: A basic architecture of cloud-based e-learning systems for higher education. In the 3rd International Conference on Smart City Applications, Springer,

Tetouan, Morocco: 319-333.
https://doi.org/10.1007/978-3-030-11196-0_29

Hazaea AN and Alzubi AA (2016). The effectiveness of using mobile on EFL learners' reading practices in Najran University. English Language Teaching, 9(5): 8-21.
https://doi.org/10.5539/elt.v9n5p8

Ishida T, Murakami Y, Lin D, Nakaguchi T, and Otani M (2018). Language service infrastructure on the web: The language grid. Computer, 51(6): 72-81.
https://doi.org/10.1109/MC.2018.2701643

Johanson B, Fox A, and Winograd T (2002). The interactive workspaces project: Experiences with ubiquitous computing rooms. IEEE Pervasive Computing, 1(2): 67-74.
https://doi.org/10.1109/MPRV.2002.1012339

Kabiri MN and Wannous M (2017). The use of cloud computing and mobile technologies to facilitate access to an e-learning solution in higher education context work in progress. In the International Conference on Applied System Innovation, IEEE, Sapporo, Japan: 1829-1832.
https://doi.org/10.1109/ICASI.2017.7988301

Margetis G, Leonidis A, Antona M, and Stephanidis C (2011). Towards ambient intelligence in the classroom. In the International Conference on Universal Access in Human-Computer Interaction, Springer, Orlando, USA: 577-586.
https://doi.org/10.1007/978-3-642-21657-2_62

Murakami Y, Tanaka M, Bramantoro A, and Zettsu K (2012b). Data-centered service composition for information analysis. In the 9th International Conference on Services Computing, IEEE, Honolulu, USA: 602-608.
https://doi.org/10.1109/SCC.2012.88

Murakami Y, Tanaka M, Lin D, and Ishida T (2012a). Service grid federation architecture for heterogeneous domains. In the 9th International Conference on Services Computing, IEEE, Honolulu, USA: 539-546.
https://doi.org/10.1109/SCC.2012.101

Mustika M, Kao CT, and Heh JS (2013). Context-aware multilingual learning based on spatiotemporal knowledge base and dynamic conversation: A system architecture. In the 13th International Conference on Advanced Learning Technologies, IEEE, Beijing, China: 179-180.
https://doi.org/10.1109/ICALT.2013.55

Paik HY, Lemos AL, Barukh MC, Benatallah B, and Natarajan A (2017). Web services–SOAP and WSDL. In: Paik HY, Lemos AL, Barukh MC, Benatallah B, and Natarajan A (Eds.), Web service implementation and composition techniques: 25-66. Springer International Publishing, Berlin, Germany.
https://doi.org/10.1007/978-3-319-55542-3_2
PMid:28813788

Pena-Rios A, Callaghan V, Gardner M, and Alhaddad MJ (2012). Towards the next generation of learning environments: An InterReality learning portal and model. In the 2012 8th International Conference on Intelligent Environments, IEEE, Guanajuato, Mexico: 267-274.
https://doi.org/10.1109/IE.2012.31

Pituxcoosuvarn M and Ishida T (2017). Enhancing participation balance in intercultural collaboration. In the International Conference on Collaboration Technologies, Springer, Saskatoon, Canada: 116-129.
https://doi.org/10.1007/978-3-319-63088-5_11

Ratto M, Shapiro RB, Truong TM, and Griswold WG (2003). The activeclass project: Experiments in encouraging classroom participation. In: Wasson B, Ludvigsen S, and Hoppe U (Eds.), Designing for change in networked learning environments: 477-486. Springer, Dordrecht, Netherlands.
https://doi.org/10.1007/978-94-017-0195-2_57

Senyo PK, Addae E, and Boateng R (2018). Cloud computing research: A review of research themes, frameworks, methods and future research directions. International Journal of Information Management, 38(1): 128-139.
https://doi.org/10.1016/j.ijinfomgt.2017.07.007

Shafi A, Saeed S, Bamarouf YA, Iqbal SZ, Min-Allah N, and Alqahtani MA (2019). Student outcomes assessment methodology for ABET accreditation: A case study of computer science and computer information systems programs. IEEE Access, 7: 13653-13667. https://doi.org/10.1109/ACCESS.2019.2894066

Shi Y, Xie W, Xu G, Shi R, Chen E, Mao Y, and Liu F (2003). The smart classroom: Merging technologies for seamless tele-education. IEEE Pervasive Computing, 2(2): 47-55. https://doi.org/10.1109/MPRV.2003.1203753

Suo Y, Miyata N, Morikawa H, Ishida T, and Shi Y (2009). Open smart classroom: Extensible and scalable learning system in smart space using web service technology. IEEE Transactions on Knowledge and Data Engineering, 21(6): 814-828. https://doi.org/10.1109/TKDE.2008.117

Uzun E, Özden MY, and Yildirim A (2015). An action research on design, delivery, and evaluation of a distance course in a vocational higher education institution. In: Kurubacak G and Yuzer TV (Eds.), Identification, evaluation, and perceptions of distance education experts: 138-166. IGI Global, Hershey, Pennsylvania, USA. https://doi.org/10.4018/978-1-4666-8119-4.ch010

Vinu PV, Sherimon PC, and Krishnan R (2011). Towards pervasive mobile learning–the vision of 21st century. Procedia-Social and Behavioral Sciences, 15: 3067-3073. https://doi.org/10.1016/j.sbspro.2011.04.247