Facilitating an Online and Sustainable Learning Environment for Cloud Computing using an Action Research Methodology

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Abstract

In this chapter, a research plan is presented to investigate online teaching and evaluation analysis for cloud computing using an action research methodology to enable sustainable learning environment. Using online teaching, we planned to conduct a thorough evaluation of the student's learning implementation in order to identify both merits and challenges. An investigation of our own teaching and learners' understanding while working together as a team on a cloud computing project has assisted us find the perfect methods for improving both. Further, we used action research methodology to analyze the literature and scholarship critically and designed best practices for action plan to facilitate an online and sustainable learning environment for cloud computing. Moreover, possible ethical concerns have been considered as students worked in a team for group project. Finally, we have discussed the plans for monitoring and evaluation of the action and impact assessment.

Keywords: Online teaching, cloud computing, assessment analysis, teamwork, engagement, sustainable learning

INTRODUCTION

In the wake of the Covid-19 pandemic, preliminary evidence from the Queen Mary University of London (QMUL) Cloud Computing module reveals that students are less engaged, more reluctant to participate, and less willing to attend classes delivered online due to the module's in-person delivery relative to the online delivery. According to the analysis findings, just 30% of participants have completed and submitted their assignments by the deadline in the year 2020, when the module was taught in-person. According to the students' feedback, it is very difficult to complete the project individually which is also very time consuming. In addition, it required considerable technical skills that some students lacked due to their diverse academic backgrounds and experiences, such as professional cloud experts, software engineers, or continuing students (Singhal et al., 2021). Several alumni acknowledged the necessity of working together to build innovative skills useful in their future career opportunities (Holtzman & Kraft, 2011). Based on informal observations of practice and consultations with colleagues teaching similar modules at other universities (Imperial College London, University of Melbourne, Cardiff University and the University of Manchester), there is a need to enhance the students' involvement and participation along with their teamwork and leadership, which are extremely important for their professional success (Kashefi et al., 2012).

Achieving the goals of this action plan will aid in the creation of an online and sustainable learning environment for cloud computing (Gill et al., 2022a).

Motivation and Contributions

Due to the good educational quality and career opportunities at Queen Mary University of London (QMUL), the number of students are increasing every year, which also contributes towards an increase in the number of students for the cloud computing module as well (Gill et al., 2023a). Therefore, it is challenging to enable engagement, primarily when students work individually on their projects. The problem emerged when students were working on their projects individually during the Covid-19 pandemic and resulted in a reduction in students' satisfaction rate by 10%. An addition of teamwork activity in this module should have improved students' engagement and technical skills and help the school and staff to manage the students' projects more effectively. We have been involved in designing a similar approach for another Indian university module, implemented successfully for teaching virtually (Singhal et al., 2021). With this approach, a lecturer can manage the workload easily with fewer administrative tasks and utilize more time to provide feedback to different groups, which assists them in completing their assignment on time and enables an online and sustainable learning environment for cloud computing to be established (Gill et al., 2023b).

The module's quality was evaluated by various stakeholders, including the discipline, employers, and students as customers following professional frameworks such as "Frameworks for Higher Education Qualifications (FHEQ)" (Qi, 2012) and "Quality Assurance Agency (QAA) benchmark statements" . They are connected to the cloud computing module's Intended Learning Outcomes (ILOs), which includes "Computing (2019)" and "Engineering (2020)." Credit Level Descriptors for Higher Education (2016) and the QMUL Statement of Graduate Attributes (QMUL, 2009) are considered to form a cloud computing module. The proposed action plan has included the following new disciplinary skills and attributes in ILOs of this module to enable a sustainable learning environment:

- Review modern cloud computing research concepts and become familiar with computing platform (Amazon Web Services (AWS) cloud) for corporate leadership.
- Apply AWS cloud to manage web services, practice what you've learned in class.
- Create an AWS-based cloud application utilising RESTful Application Programming Interface (API) services to improve your teamwork skills.
- Develop an application using AWS cloud and exhibit their capability to work with other people to know about the spirit of collaboration.

Lab activities have been updated to reflect the most current professional standards by including the latest software tools. Teamwork activities were included in this course to understand the essential teamwork skills they would need for career advancement. On the first day of cloud computing module, students choice regarding coursework was asked using Mentimeter. 196 students have participated in this survey and 81.1% students preferred group based lab project while only 18.9% voted for individual lab project. This students also indicates that teamwork is an important activity which must be included to improve students teamwork skills while working in a team, which offers more sustainable learning environment (Gill et al., 2023c). To further motivate learners to participate in online contests, compete in MSc research, join internship programs, and unlock the doors to career prospects, the module allows learners to undertake numerous online courses and certifications on these tools.

The rest of the chapter is structured as follows: Second section gives the background to discuss use of an action research methodology to offer an online and sustainable learning environment. Further, we discuss the evaluation of existing practice in third section. Fourth section presents the review of literature. Fifth section gives the details of methods to inform and evaluate the action. Sixth section discuss the limitations and ethical constraints. Seventh section presents an approach for monitoring and evaluation of the action along with impact assessment. Eighth section shows the preliminary

results nineth section gives the discussions and offers recommendations for potential readers. Finally, last section concludes the chapter. The detailed description of data gathering tools is given in Appendix 1. Appendix 2 gives the procedure used for addressing ethical concerns.

ADOPTING AN ACTION RESEARCH METHODOLOGY AND BACKGROUND

By adopting an Action Research (AR) methodology to investigate practice, educational practitioners can investigate their practice, solve problems and generate change to enable an online and sustainable learning environment for cloud computing. In the context of Higher Education, this methodology gives academics a tool to address concerns like, "How do I enhance my practice?" and develop small-scale context-driven initiatives that are established to solve particular challenges related to the requirements of students and staff advancement and institutional goals or explore an area of interest or concern for sustainable future (Carr & Kemmis, 1986) (Elliott, 1991) (Lewin, 1946) (Stenhouse, 1975). AR encompasses a cycle involving: reflection on practice and collection of information to inform the design of the action, action planning, implementation of the action, collection of data, reflection on the outcomes and results and consideration of the need to start new cycles. According to Lambirth & Cabral (2017), action research can be regarded as a tool for professional learning due to its ability to integrate systematic research into the daily work of practitioners.

Collaborating with peers, exchanging thoughts, discussing viewpoints, and engaging in genuine conversations with students are all essential components of action research (Naeem et al., 2022). This collaboration in knowledge development is continuously challenged by the restrictions and limitations of power relations. However, action research can become a transformative strategy in terms of professional learning with practitioners using it to (re)claim agency and tailor their practice to their own needs, the needs of their students and the contexts in which they work (Lambirth et al., 2019).

In the field of education and information technology, action research can help practitioners answer the particular demands of the 21st century to develop more sustainable learning environment. As argued by Glassman (2020) 'education must take new approaches to meet the social opportunities and challenges brought about through the information revolution, in particular access to new information, capabilities for new types of communities that can challenge place-based agendas, and distributed power and voice' (Amstelveen, 2019). In this article, authors have discussed how action research was used to investigate the use of a flipped classroom in college-level Mathematics (Amstelveen, 2019) and analyzed the postgraduate information systems module's communication skills (Isaias & Issa, 2014).

Furthermore, we have tested and developed strategies to improve classroom design and teaching methods for teaching critical transferable skills to computer science and engineering students in a sustainable learning environment (Burrows & Borowczak, 2019). Based on students' feedback, assessment results, informed observations and considering the role of other stakeholders, we have identified various critical challenges (Figure 1) that motivate us to design a new research plan for cloud computing and enable sustainable learning environment for cloud computing. To address these issues, we have studied the effectiveness of a novel team-based virtual lab activity on the learning process of students enrolled in a Cloud Computing course as an outcome of this research (Junco, 2012). Through this approach, students can acquire the required benefit and support from the staff, school, university and Higher Education (HE) to improve their careers (HEA, 2015).

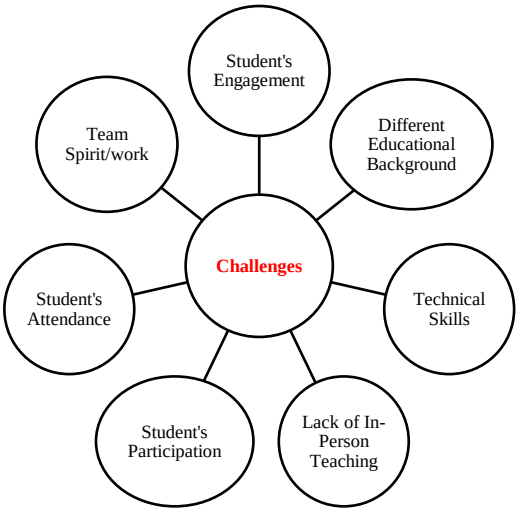

Figure 1: Important challenges in practice to enable sustainable learning environment for cloud computing

EVALUATION OF THE EXISTING PRACTICE

We have applied the action research model to the cloud computing module through different steps: i) plan, ii) act, iii) observe and iv) reflect (Zuber-Skerritt, 2021). The first step is "Plan" for action research to evaluate existing practice by considering various important factors. These factors include students' feedback, evaluation results, reflection log, informal discussions with students, observations by focus groups and colleagues and review of the literature and scholarship (Figure 2).

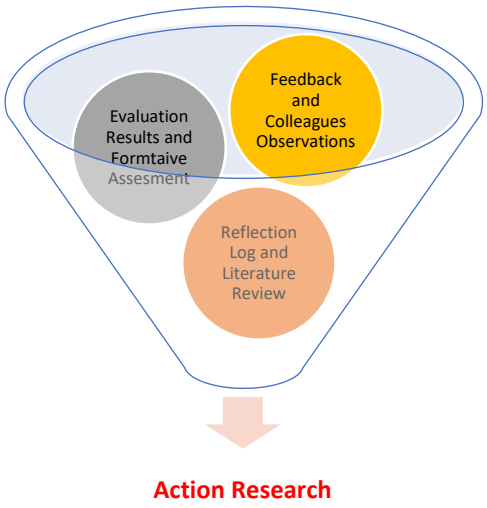

Figure 2: Important factors are considered for evaluation of practice

Through this action research, we have implemented (act) the above discussed plan by delivering this module using various well-proven active learning activities. These activities include online webinars, H5P-based interactive videos for each topic (Homanová & Havlásková, 2019), problem-based learning (PBL) pedagogy (think-pair and share) to enable teamwork (Alves, 2012), group discussion through drop-in sessions (Giannini, 1999), lab quizzes (Geiger & Bostow, 1976), and interactive Q/A sessions using web-based tools such as Mentimeter and Kahoot (Gokbulut, 2020). Students have given feedback after each online session through Google survey forms, which helped us adapt the teaching practice as needed during the module delivery. This module has been delivered by lecturers and four senior demonstrators using a virtual environment which improves learner engagement as seen in law education (Brooman, 2011) and microbiology (Sancho, 2006). Figure 3 illustrates how Bloom's taxonomy (Sosniak, 1994) (shown at several levels) was allocated resources effectively to

implement a research plan. Bloom's Taxonomy is a valuable tool for improving the ability to think critically and tackling real-world issues with innovation, which has been utilised successfully in many disciplines such as science and engineering (Hager et al., 1994), sustainability (Pappas et al., 2013) and music education (Hanna, 2007) to enable a sustainable learning environment. The first two lower levels **(Remember and Understand)** of Bloom's taxonomy have explored essential ideas by reading the research papers and viewing the interactive videos.

Further, participation in the Mentimeter/Kahoot quiz during the online session and answering questions on QMPlus (Virtual Learning Environment (VLE) at QMUL) after the online session have improved understanding of the current topic (Gill et al. 2023a). While working through the lab tasks, the demonstrators have supported Bloom's taxonomy's third level **(Apply)**, including learning about the newest cloud computing and software solutions, such as AWS (Gill et al., 2022b). Demonstrators helped learners diagnose errors while doing activities, creating very dynamic laboratory sessions for online learning **(Analyse)**. Lab quizzes for self-learning are designed to assess students' understanding of various lab tasks **(Evaluate)**. Four drop-in sessions was used to clear students' doubts, including group discussions, real-world applications, and forming teams (Gill et al. 2023b). The students then analyzed their mini-projects utilizing the think-pair-share activity. Students can choose the domain/area/programming tool they want to work in **(Evaluate)**. To develop a cloud application, the team must come up with original ideas based on group conversation and prior experience in similar projects **(Create)**.

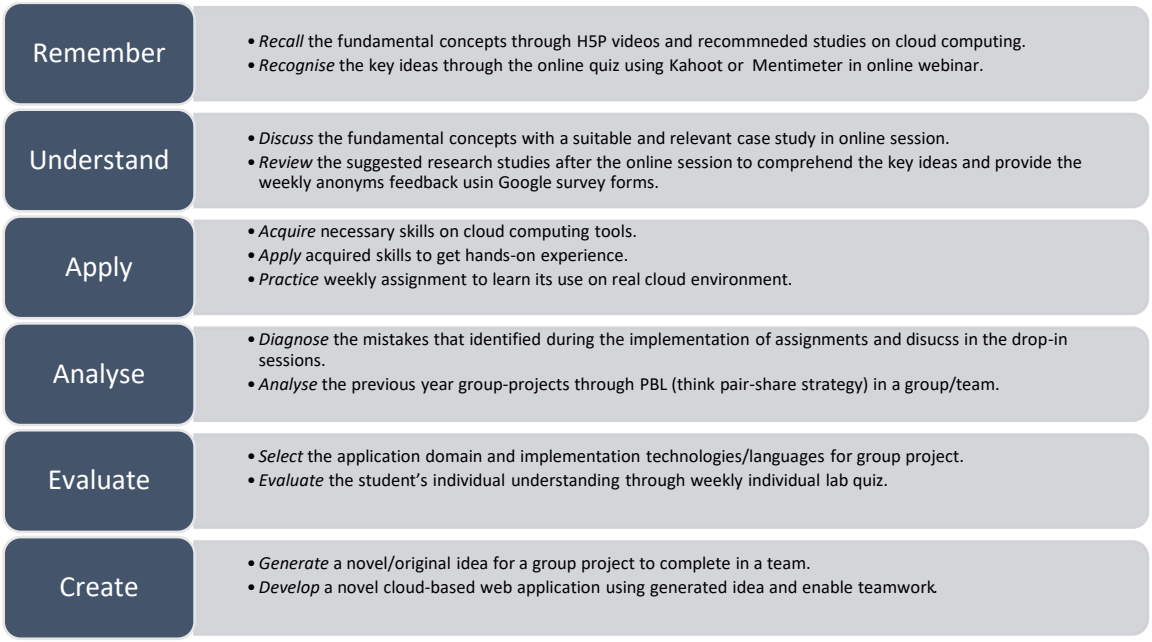

Figure 3: Applying Bloom's taxonomy to learn Cloud Computing

We have **observed** the impact of action research on students' learning through feedback, formative and summative assessments. Finally, we have **reflected** based on students' feedback, evaluation results, informal discussions with students, observations by focus groups and colleagues, and reviewing the literature and scholarship, which helped us improve teaching practice to enable an online and sustainable learning environment for cloud computing.

ANALYSIS OF LITERATURE

On the basis of current research, we have developed an action approach to allow an online and long-term learning environment for cloud computing (Gill et al. 2023c). For example, during the COVID19 pandemic, a digital device-based active learning strategy for online education was developed (Singhal et al., 2021). Academics form QMUL were on a research team. Teamwork activities were used to

execute this task at the University of Petroleum and Energy Studies (UPES) in India. This method boosted students' learning ability and increased average scores in two engineering disciplines by 66.9%. The success of this strategy in an Indian institution inspired us to use it for our cloud computing module to offer an online and sustainable learning environment.

Also, at Indiana University, a collaborative exercise to improve student interest, involvement, and attention was examined (Cavinato et al., 2021). The feedback of 6,000 undergraduate students showed teamwork-based practical learning activities enhance students' enthusiasm and willingness to study. Students believed it was more interactive, which increased attention, attendance, technical abilities, and favourable student relationships. The research also shows that students are more likely to succeed when given a flexible deadline for their projects and assignments. This evidence helped us increase student teamwork, involvement, and attendance in cloud computing module. Another study (Kapilan et al., 2021) may lead to a new instructional approach for completing virtual laboratory experiments in mechanical engineering courses. According to participant feedback collected through questionnaires, focus groups, and interviews, the learning process and student involvement increased across nine courses. Effective utilization of problem-based learning (PBL) for teamwork skills improved student engagement and was useful for our research plan to offer a sustainable learning environment. According to student comments, online learning is also less participatory and impairs students' capacity to self-learn. Another piece of research (Pazos et al., 2020) looked at the impact of interdisciplinary undergraduate partnerships on teamwork efficiency. The authors observed that performance in terms of problem-solving and technical abilities improved considerably due to using a start-stop-continue feedback strategy. Another study (Gunawan et al., 2017) glanced at how learning electricity online affects problem-solving skills and recommended that trained demonstrators improve students' learning. We have used this for our action research to improve teamwork skills. Further, AWS cloud-based training was provided to cloud computing demonstrators under AWS Programs for Research and Education which improved their knowledge and enabled long-term students' learning.

Another study (Gerstenhaber, & Har-El, 2021) used virtual laboratories for a biomaterials course, and students were examined individually and in groups. They assessed the module's effectiveness across ethnic and cultural groups using web-based questionnaires and laboratory data (Luse & Rursch, 2021). The student opinions reveal that working individually and in teams was advantageous when implementing our action plan for coping with diversity. Pre-recorded videos must be uploaded on each topic to provide them better understanding of important concepts before participating in the lab. Another study (García-Peñalvo et al., 2021) from four Spanish institutions discusses enhancing online assessments—an exciting vision for ongoing assessment during the delivery of the cloud computing module. The researchers say that to administer the evaluation method properly, students must be informed beforehand about evaluation criteria. Another piece of research (Yusuf & Widyaningsih, 2020) acknowledged participants' metacognitive talents while doing online Physics activities. These skills were assessed qualitatively using video recordings of classroom discussions and quizzes. Students could ask and answer questions in a customizable virtual classroom, and 97.6% of the students took online quizzes. Their feedback indicates that weekly quizzes reduce stress and increase cognitive, psychological, and interpersonal engagement, which suggested that this was worthy of adoption in our research plan to make more sustainable module (Hughes et al., 2020).

Learning chemistry in a virtual environment can help students better comprehend key ideas by employing simulations, videos, animations, and images (Achuthan, & Murali, 2017). 524 undergrads were assessed online and in-person using evaluation questionnaires which shows its effectiveness for student engagement and also help dyslexic students the most. Therefore, we have included active learning tools and approaches into cloud computing curriculum to make this module more sustainable in terms of learning and teaching. Similarly, another study (Achuthan et al., 2017) assessed various aspects such as knowledge transfer, analogical reasoning, and metacognition. They used multiple-choice questions (MCQs), questions and answers (Q/A), and True or False (T/F) statements. Using an H5P based interactive video pre-lab fosters active learning, which was included in our strategic plan. According to the feedback of 145 students who participated in this research, studying in a virtual

classroom is superior to learning in a physical lab, and incorporating these learning elements improves critical thinking. Uncovering an online computer networking lesson to increase students' awareness of 'business' configuration settings is examined in another research article (Gerstenhaber, & Har-El, 2021). It appears that this technique improves students' technical skills, which in turn improves their deliberate process at the highest levels of Bloom's taxonomy, allowing them to produce creative solutions to the problem at hand. This study was helpful for cloud computing students to improve technical skills using Bloom's taxonomy to create innovative ideas for their team projects, which assisted to sustain this teaching practice for long time. Similar studies (Hoegl & Parboteeah, 2007) (Baker et al., 2016) examined learners' creative and critical thinking abilities while collaborating to achieve a common objective, but we have applied this study to cloud computing cautiously, given a negative correlation between team performance and creative thinking.

Critical Analysis

Table 1 compared the proposed action plan with existing literature. It has been noted that all the above-mentioned works presented approaches for an online and sustainable learning environment except the work done by García-Peñalvo et al. (2021), which is for in-person teaching. Investigation of the published literature (Singhal et al., 2021) (Gerstenhaber, & Har-El, 2021) (García-Peñalvo et al., 2021) (Hughes et al., 2020) indicated that different kinds of feedback (weekly questionnaires based and mid module feedback) and formative assessments (Q/A and Kahoot or Mentimeter based quizzes) during the delivery of module could improve students' engagement, participation, attendance and performance in the virtual environment (Gill et al. 2023a). It has been clearly shown that authors considered summative and formative assessments and multiple feedback forms (García-Peñalvo et al., 2021). However, the inclusion of various activities for feedback and formative assessments reduces students' interaction (Naeem et al., 2022). It hinders their ability to self-learn, according to the feedback collected from the students in another study (Kapilan et al., 2021). Various studies (Singhal et al., 2021) (Cavinato et al., 2021) (Kapilan et al., 2021) (Pazos et al., 2020) showed that teamwork is an important activity to improve student engagement and enable an online and sustainable learning environment. Problem Based Learning (PBL) pedagogy can be used for teamwork activities to enhance problem-solving abilities (Kapilan et al., 2021). However, the impact of teamwork on students' attendance, participation and performance is missing in the literature (Gill et al. 2023b), which is most important component to enable sustainable learning environment for cloud computing.

Further, no study has identified the impact of students' learning technical skills in a team with their different culture, nationality, educational background or experience, age of students, ethnicity, race and gender (Gill et al. 2023c). Various drop-in sessions can be organised for helping the students to complete their group projects in a team. Further, active learning activities such as H5P based interactive videos, online quizzes, group discussion activities and interactive Q/A sessions can be used for formative assessments to improve students' engagement (Gerstenhaber, & Har-El, 2021) (García-Peñalvo et al., 2021) (Hughes et al., 2020) (Achuthan, & Murali, 2017) (Achuthan et al., 2017). Literature also reported that implementing multiple active learning activities for large classes is very challenging, requiring effective time management and planning in advance. Further, it needs a substantial amount of time to mark these assessments. Integration of these activities with online teaching platforms such as QMPLUS have saved the tutor's time and offer easy marking. The regular utilisation of these teaching tools can improve the personal and professional development of the lecturer. We were inspired to use Mentimeter based quizzes (formative assessment) during the online session, enhancing student engagement. Later, it will help students do their weekly individual quizzes (summative assessment) effectively after every lab to evaluate their individual performance (Geiger & Bostow, 1976). The utilisation of Mentimeter-based quizzes can further improve students' attendance and participation (Gill et al. 2023a). Most of the above-mentioned literature used written exams and individual projects as summative assessments for student's evaluation, which are the main reasons for lacking student engagement. The utilisation of formative and summative assessments and other active learning activities can improve students' engagement, participation, attendance, and

performance in a virtual environment (Gill et al. 2023b). This research plan adopted the evidence from the literature and scholarship to improve the students' learning for the cloud computing module to facilitate an online and sustainable learning environment.

Table 1: Comparison of proposed action research study with existing works

Work	Online	Drop-in Sessions	Teamwork	Focus of Study (Sustainable Development)			Assessment	Feedback	Evaluation Approach
				Engagement	Attendance	Participation			
(Singhal et al., 2021)	✓		✓	✓	✓	✓	Summative	Online quizzes based feedback	Group Project
(Gerstenhaber, & Har-El, 2021)	✓			✓			Summative	Final Module Feedback	Written Exam and Individual lab viva
(Cavinato et al., 2021)	✓		✓	✓	✓	✓	Summative	Final Module Feedback	Group Project
(García-Peñalvo et al., 2021)	✓						Summative and Formative	Weekly Questionnaires based, Mid Module and Final Module Feedback	Written Exam
(Kapilan et al., 2021)	✓		✓	✓			Summative	Final Module Feedback	Group Project
(Yusuf & Widyaningsih, 2020)	✓						Summative	Final Module Feedback	Written Exam
(Hughes et al., 2020)	✓			✓		✓	Summative	Online quizzes based feedback	Written Exam and Individual lab viva
(Achuthan, & Murali, 2017)	✓						Summative	Final Module Feedback	Written Exam and Individual lab viva
(Achuthan et al., 2017)	✓						Summative	Final Module Feedback	Written Exam
(Luse & Rursch, 2021)	✓						Summative	Final Module Feedback	Individual lab viva
(Pazos et al., 2020)			✓				Summative	Final Module Feedback	Group Project
(Zeni, 1998)	✓						Summative	Final Module Feedback	Written Exam
(Gunawan et al., 2017)	✓						Summative	Final Module Feedback	Individual lab viva
(Hoegl & Parboteeah, 2007)							Summative	Final Module Feedback	Written Exam
(Baker et al., 2016)	✓						Summative	Final Module Feedback	Individual lab Project
Our Proposed Action Plan	**✓**	**✓**	**✓**	**✓**	**✓**	**✓**	**Summative and Formative**	**Weekly Google Forms Survey, Mid Module and Final Module Feedback**	**Individual Lab Quiz and Group Project**

METHODS TO INFORM AND EVALUATE THE ACTION

In light of our previous experiences from teaching, we have defined methodologies which were used to inform and assess out action to facilitate an online and sustainable learning environment for cloud computing module at QMUL (Gill et al., 2022).

Evidence 1: We have used the following methods to inform our action:

- For questions such as i) how can we improve student engagement and teamwork skills during online delivery of module; ii) how can we evaluate student performance using different types of tools, and iii) what are the different types of feedback that we can use to understand the student's learning, an **academic literature review** will be used to inform questions.
- **Professional frameworks** such as "Quality Assurance Agency (QAA) benchmark statements", "QMUL Statement of Graduate Attributes", and "Frameworks for Higher Education Qualifications (FHEQ)" were used to determine the appropriate level of disciplinary skills & attributes, and then designing activities in line with this to attain the ILOs.
- We have kept a **reflective log** of our practice to highlight problems we have discovered with the present assessment system. These problems include gaps in our knowledge about managing teamwork; and practical problems in students' understanding.
- Data from prior **assessments and evaluations** also utilised to identify problems with the current assessment from the students' viewpoints, such as whether or not they reported issues with it and whether or not they did satisfactorily on them.

- Another method is to engage in debates on most effective methods for engagement (including teamwork) with colleagues from other institutions teaching the same module at QMUL and other universities (Manchester University, Melbourne University and Imperial College London). Further, teaching observations and informal conversations with colleagues about the **assessments and feedback** were used to inform action.
- We intended to use student **feedback** to identify areas where we can improve. The insights obtained will help improve the delivery of online labs and lecturers in the future.

Evidence 2: We have identified the following methods to evaluate the action:

- The **academic literature** is providing a benchmark against which our results may be evaluated and a guide to the methodologies used in conducting this evaluation. Using a **literature review** on active learning approaches, we are tracking students' performance and determine what influences team members' learning.
- For **Virtual Learning Environment (VLE)** reports and analytics, we intended to provide lab quizzes, project reports from the previous year, interactive videos based on H5P and presentations using QMPLUS to the students in order to aid them in completing the lab exercise. This also provide us with the opportunity to do engagement analytics on QMPLUS. For the aim of achieving the action plan to make it more sustainable, this module was delivered through a combination of online video lectures and active learning activities, which has included Problem Based Learning (PBL) pedagogy using MS Teams or Zoom, group discussion sessions, lab quizzes, and interactive Q/A sessions using web-based tools such as Mentimeter, Kahoot and Google forms. These active learning tools and techniques will provide statistical data of students' engagement, participation, attendance and performance.
- Statistics from assessments and evaluations are used, compared the findings to those in prior years. We used **summative assessments** (individual lab quiz and group project) and formative assessments (Mentimeter or Kahoot based quiz during online session and weekly Google survey forms after the online session) to evaluate the cloud computing module. Data collected from students, assessment results, grades, and interactions with colleagues who teach cloud computing courses also considered. Learners' presence and test performances (individual assessment grades and the overall grades) have also taken into account when determining their ILO success.
- For example, a **reflective log** of our experience running the assessment helped note how many students interact during drop-in sessions. It was necessary to keep a reflection record during the project's duration to identify barriers in teaching practice and put countermeasures in place. Our existing teaching practice was evaluated, and development opportunities were identified through action research. We were also able to experiment and gather data that will aid us in discovering the most successful and sustainable techniques to enhance teaching and students' learning for long-term. **Formative assessments** were used to evaluate the participants' involvement. Further, we were tracked their performance by conducting a literature review on active learning methods to identify the participants' learning factors.
- Another method that has been identified in the literature is a **focus group**. This allowed for more in-depth qualitative research of students' learning both in teams and individually. To assess and examine participation following the intervention, we used the opinions of our colleagues as well as inputs from the interview session of the focus group.
- Through the use of **external observers** (colleagues from QMUL or other institutions), we assessed our research activities, and the comments we have received assisted us to enhance our teaching practice for facilitating sustainable and online learning environment for cloud computing module.
- A variety of **feedback** methods were used to assess the performance of ILOs, including a weekly Google Forms survey, mid-module and final-module feedback, and alumni input from students who have progressed on to successful careers. Google surveys was used to get anonymous student feedback on weekly material. A Traffic Light Model have assessed students' remarks and improve our teaching approach and methods when it comes to this feedback. Reflective action have boosted student engagement when students find it challenging to learn a particular topic.

Semi-structured Data and Advanced Data Modelling module in semester A at QMUL noticed an improvement in student satisfaction when we used the same method. Aside from that, we have collected mid-module input from students using QMPlus-based mid-module feedback. This feedback was used to monitor and track the development of ILOs, which was beneficial to students working on lab assignments and other course-related concerns. In the second session, students' final remarks were used to evaluate their overall satisfaction with the way the course was delivered.

The detailed description of data gathering tools is given in **Appendix 1**. Our action study was implemented following a timeline for feedback and assessments (Figure 4), which we developed in accordance with the methodologies for evaluating the action (Gill et al., 2023b).

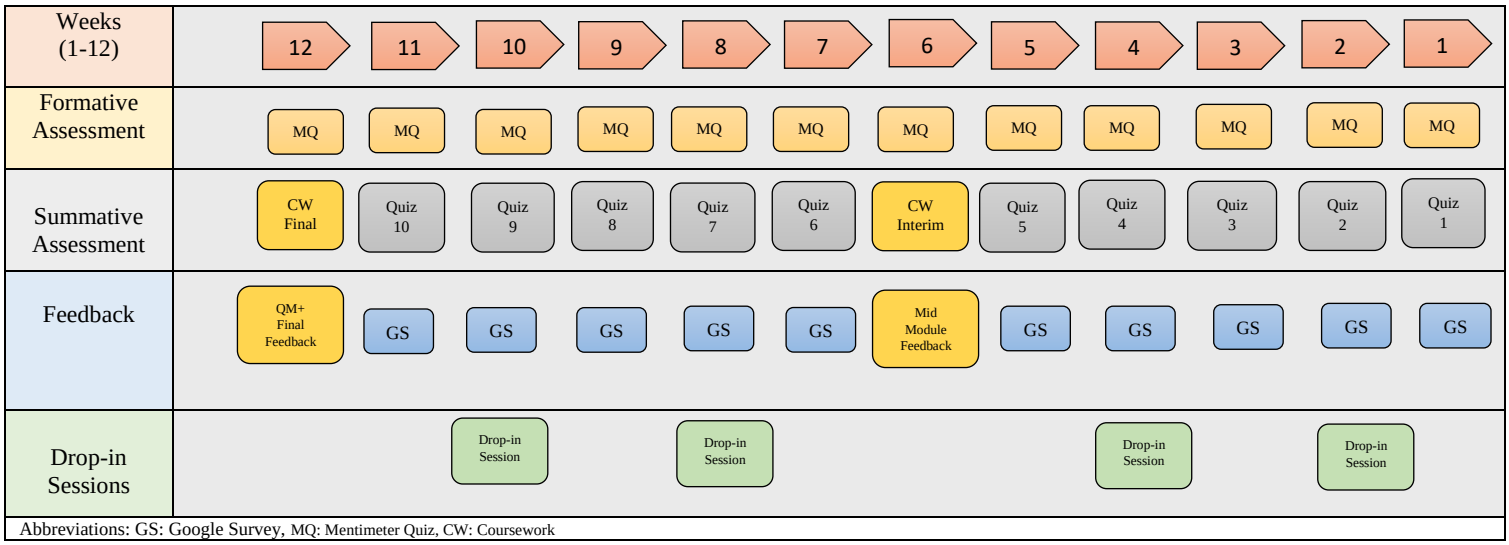

Figure 4: Timeline for Assessment and Feedback

LIMITATIONS AND ETHICAL CONSTRAINTS

We have considered moral standards specified in the QMUL ethical policy (QMUL, 2022) and the BERA principles (BERA 2018) in this action research. It is critical to think about ethical concerns daily, in addition to undergoing formal ethical evaluation and approval, as advocated by Kemmis and McTaggart (1988). We intended to carry out our study plan according to the ethical standards outlined by Zeni (1998), engage students only with their consent, and treat them all equally and with respect as recommended by Cohen et al. (2011). During the implementation of our study plan, we have looked out for ethical challenges that can occur in our everyday activities (Gill et al. 2023c). Following the findings of our action study, students collaborated to accomplish their group projects (Naeem et al., 2022). The collection of data regarding participants' experiences working in groups have faced various ethical and moral problems, such as the confidentiality of students' data and their anonymity and the possibility of victimisation.

- Loss of anonymity: For this project, every student was required to disclose their interests and skills on a shared platform (for example, Google forms) to build online groups based on their interests and programming skills.
- Loss of confidentiality: All of the other students' data, including their personal and academic information, were available to all of the other students in the class.
- Potential victimization: When there was more considerable diversity in terms of culture, nationality, educational background or experience, the age of students, ethnicity, race, and gender, internal disagreements or conflicts were emerged due to this greater diversity.

Among the steps we were taken to mitigate these ethical risks is to make announcements at the beginning of each lab session about crucial topics, such as accepting responsibility by all participants to maintain confidentiality (Kemmis, & McTaggart, 1988). As a researcher and a teacher, our role in this action plan was multifaceted. However, we have proceeded with utmost caution and ensured that all data was maintained securely and acceptably (BERA Guidelines (BERA 2018)). Additionally, we have used information sheets to clarify the terms and conditions and written consent to guarantee that recognized practice standards are maintained while adhering to the QMUL ethical policy (QMUL, 2022). Following the General Data Protection Regulation (GDPR), a password and the participant's right to withdraw were used to protect the confidentiality of the information gathered throughout the study (UK GDPR, 2018). We have wished to study the action plan for the cloud computing module (BERA Guidelines (BERA 2018)) mainly because our primary goal was to evaluate the module's delivery and improve our teaching practice (Zeni, 1998). A weekly evaluation of each group's progress was conducted to verify that they are on track to meet their objectives (Kemmis & McTaggart, 1988). A student who were not feeling comfortable in a group because of greater diversity were allowed to work alone or join another group with our prior agreement if they so want. Data confidentiality, student permission, and the ability to join or quit a group have been highlighted in the literature (Gunawan et al., 2017) to boost students' performance and participation in a project, which made this module more sustainable. **Appendix 2** gives the procedure which were used for addressing ethical concerns.

MONITORING AND EVALUATION OF THE ACTION

As a result of the intervention, we anticipate that students' attendance, participation and engagement have improved. Figure 5 shows the sequence of steps that were used to implement the action plan to facilitate an online and sustainable learning environment. Research plan pathways was divided into five main parts: 1) inputs, 2) activities, 3) outputs, 4) outcomes, and 5) impacts. In addition, we have considered feedback (Google survey forms data, mid-module and final QMPLUS feedback, colleagues observations and feedback from alumni and previous year students), formative assessment (Mentimeter or Kahoot-based quizzes during the lecturers), summative assessment (lab quiz and coursework marks) and prior evaluations (grades and results from previous year students) as **inputs** to the research.

The next part of the research plan pathway was **activities** that included students watching H5P-based Interactive videos to understand basic concepts, attempting lab quizzes after each lab (from week 1 to week 10), working on group projects in a team, participating in the Mentimeter quizzes during the online session to check the understanding of concepts, Q/A on QMPLUS and drop-in sessions to discuss concepts and clearing students doubts. The third part was **outputs** of an implemented research plan, which included evaluation results including students' grades, assessment marks including lab quizzes marks and group project marks, statistical data which showed the interaction of students with H5P based videos, quality of group project report including format, structure, figures, tables & references and working prototype of a group project. We have monitored the action through the first three parts of the research plan pathways (inputs, activities and outputs) and which can be controlled based on the mid module feedback and formative assessment during the module.

The fourth part of the research plan pathway will be an **outcome** in learning teamwork skills, technical skills, and how teamwork can improve students' careers. Then, we will consider the outputs and outcome of the research plan pathway to evaluate the action plan. The final part of the research plan pathway will be impacts, including student engagement, attendance, participation, and performance. Further, impact analysis will be done by using both **outcome** and **impacts**, while outcome gets direct influence and impacts gets indirect consequence of the research plan.

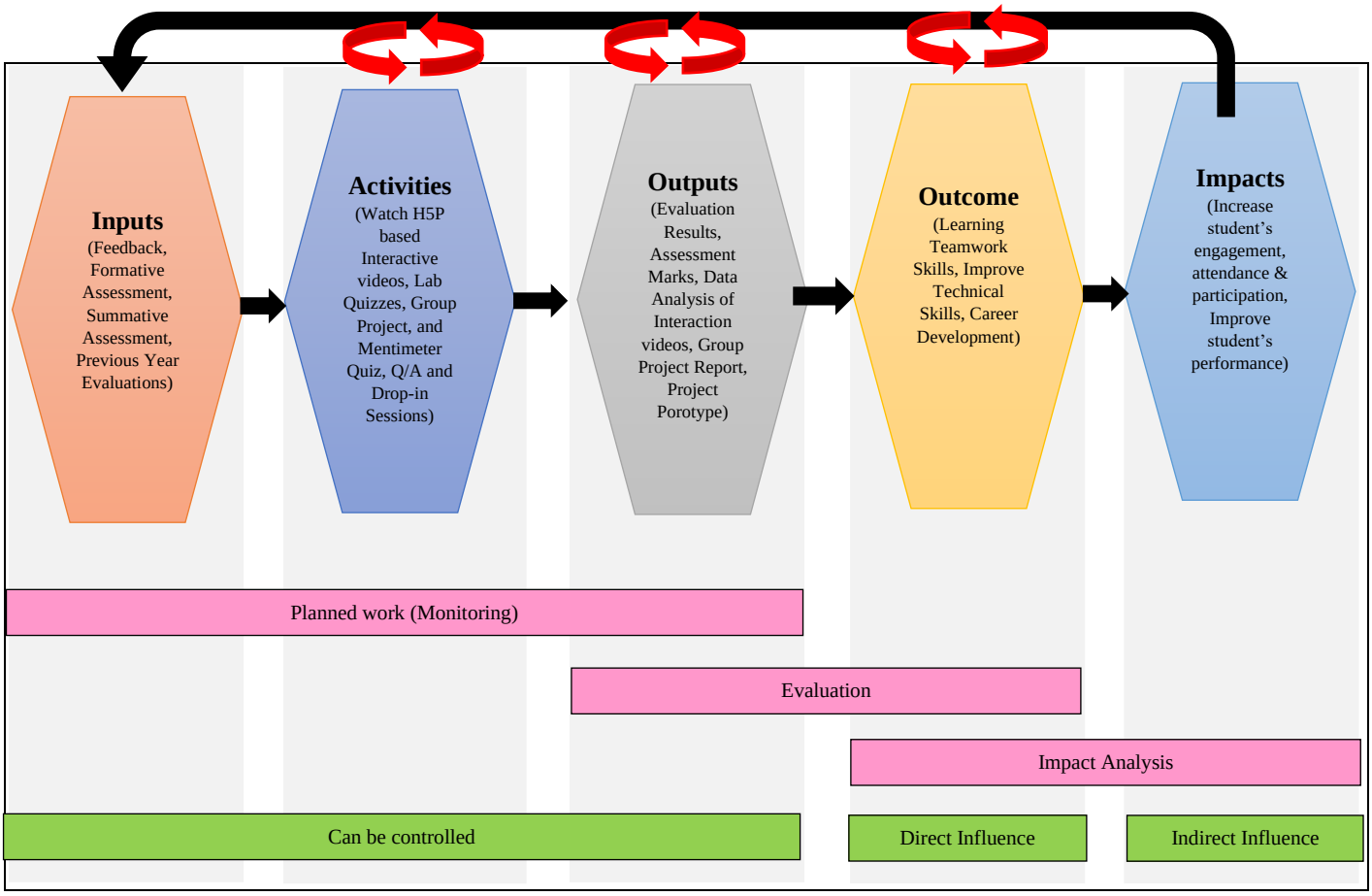

Figure 5: Research Plan Pathway

PRELIMINARY RESULTS: DATA ANALYSIS AND FINDINGS

This section highlights the important findings in the form of preliminary results to show the effectiveness of our research plan.

Formative Assessments

In every online session, we have used Mentimeter quizzes for two different purposes: 1) first quiz to test the previous knowledge of students before starting the lecture and 2) second quiz to check the gained knowledge after this session. For the academic year 2021–2022, 190 students at QMUL were enrolled in the Cloud Computing module and we have tested our action research plan by teaching cloud computing to these students. Statistics revealed that every week, at least 152 students took the Mentimeter questionnaire, demonstrating that the use of web-based tools order to increase student participation in virtual learning.

Feedback

We have collected anonymous feedback using Google surveys and QMPLUS, where 50% students have participated to share their views on the online delivery of cloud computing module. This feedback shows that most of the students were very satisfied with this action research plan. Students have mentioned that the use of various active learning tools helped them to connect with the course content. It has been stated that use of web-based quizzes assisted students to maintain their attention

during the online session. We have received important suggestions including the utilisation of video tutorials for every laboratory activity, lab-specific practical exercises, and a reduced number of learners partaking within every laboratory activity. Each of the laboratory assignments will have pre-recorded videos available the following academic year (2022-23), and learners will be able to make a start on them straightaway. There will be review meetings for the labs during reading week (after completing the 50% delivery of module), and we will give one more supporting session to the students to finish any incomplete assignments at the end of the module. The majority of learners were happy with this teamwork activity for their profession, according to comments that were collected to better understand individuals' perspectives on teamwork, career, and teaching methodology. Students also highlighted how valuable the modern tools and technology they learned in this module were for their careers. According to further input on the learning ideas, the majority of students considered them to be extremely beneficial for their career. Students are extremely satisfied with the teaching approach adopted to deliver lessons through this action research plan, according to their overall analysis on the teaching and learning process.

Analysis

Based on the formative assessments and collected feedback, it is clearly shows that this action research plan has enhanced students' teamwork and technical skills, increased engagement and participation of students and also helped them to find the jobs in the area of cloud computing. Further, this research plan has assisted us to deal with diversity in an efficient manner.

Positive aspects of the action research plan

Comparatively to the last year, when significant modifications were made as a result of virtual teaching, the action plan has developed. On the whole, the lessons and offered material were better organized. In order to give learners practical exposure, laboratory activities and assignments are now designed on a AWS Cloud to give real time cloud experience to the students. Each student has learned how to collaborate with others through the group project. Each group turned in their assignments on time, and the majority of learners completed their laboratory tests in a timely manner. The answers to the practice queries have been submitted by certain students each week.

Negative aspects of the action research plan

For the team work activity, several participants' collaboration was incredibly lacking. A few students failed to participate in the laboratory quizzes based on weekly lab exercises, which had an impact on their overall scores obtained in this module. A tiny but vocal number of students without an education in computer science often objected that this action research plan was too advanced and too challenging for them. We set up five drop-in sessions for everybody in different weeks, but a few participants were unwilling to listen to our instructions and persisted in having this attitude throughout the whole semester.

The majority of comments were really favourable, which clearly shows the effectiveness of research plan. The majority of learners strongly complimented the material and viewed it as being really helpful for their future careers. Since working with others during teamwork/group project is challenging owing to online learning, the group project received a number of critiques. We would take into account different group project-based comprehensive case studies for dealing with diversity in the next year. We have provided a thorough study of how the modifications made during action research plan have affected the input from students. While we continue using this strategy in the next year, we will consider feedback when analysing the impact of action research plan on learners' employability.

DISCUSSIONS AND RECOMMENDATIONS

This investigation helped us to gain much insight into my practice as a teacher and researcher and how to better help students with a teamwork-based project in their preparation for the future. During the implementation of this plan, we have analysed how students' involvement, performance, and attendance affected their careers and how working in a team has helped these students to develop their abilities (Gill et al., 2023b). We have implemented this action research plan at Queen Mary University of London (QMUL) for Cloud Computing module successfully and it will serve as an example for promoting teamwork at the school and institution levels in the future. This work will act as a benchmark for other schools at QMUL and other institutes to facilitate an online and sustainable learning environment for other modules of Computer Science and other disciplines (Gill et al., 2022). This action plan have improved teaching practices for our personal, academic and professional development as shown in Figure 6.

Based on students' feedback and assessment results, we have identified the important areas of development to improve research plan for cloud computing and other modules of Computer Science and Engineering for making robust and sustainable learning environment. Further, we have created focus groups to study the direct and indirect impact of a novel team-based virtual lab activity on the learning process of students, and their feedback showed that teamwork is very useful to develop their teamwork and technical skills. Further. this study heled postgraduate students to get the necessary assistance and support from the staff, school, university and Higher Education (HE), which has improved their personal and professional development.

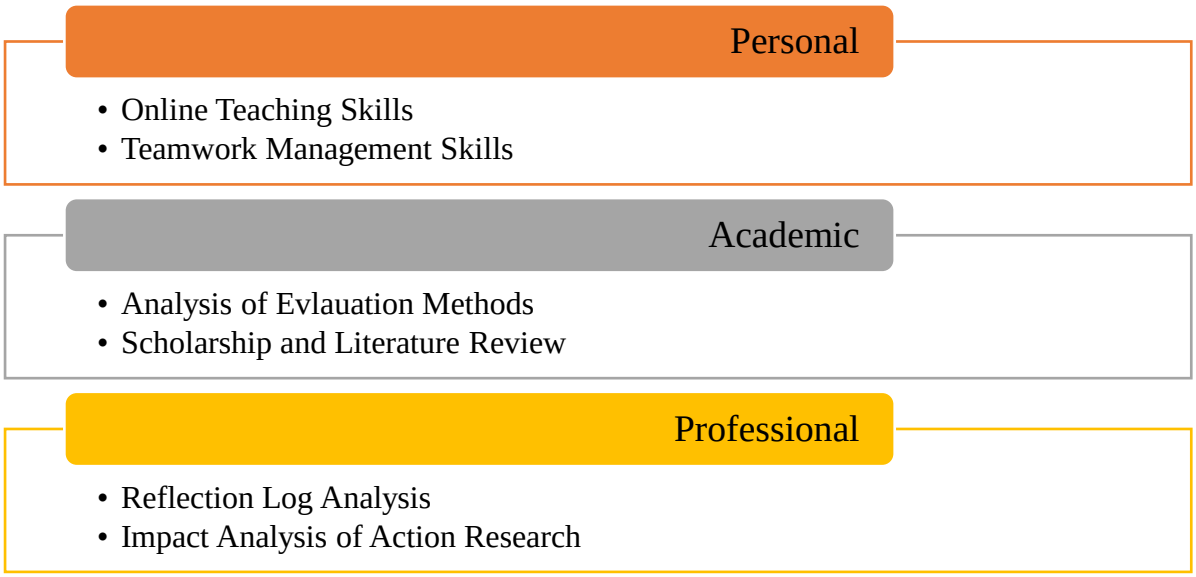

Figure 6: Improved key development areas during Action Plan

We have noted that the implementation of this research plan at QMUL has helped students of Computer Science and Engineering directly for the improvement of their thoughts on engagement, their opinions on what Computer science education is presently giving them, and their recommendations on how we can further promote student participation in the future. The successful implementation of this action research plan have encouraged students to share their own opinions with others throughout the process through various types of formative assessments and feedback types. Further, this action research plan will be implemented for face to face teaching in the post-Covid era. Prospective researchers and teachers can use this effective research plan for teaching other modules of Computer Science and other disciplines to understand its effectiveness and identify the further areas of improvements.

CONCLUSION

In this chapter, we outlined our action research plan for investigating cloud computing-based online laboratory assessment analysis to facilitate an online and sustainable learning environment. This proposal has been designed to evaluate how well students have learnt using virtual laboratories to see where they were succeeding and where they were failing. While working on a cloud computing project together, we understood our own teaching and the comprehension of our students to offer sustainable learning and teaching environment. To come up with the finest strategies for action, we studied the literature and scholarship rigorously in this study to build a foundation for the development of sustainable environment for online learning. As students collaborate on a group project, potential ethical issues have been taken into account. Lastly, we have discussed about the strategies for monitoring and evaluation and impact assessment.

APPENDIX 1: DETAILED DESCRIPTION OF DATA GATHERING TOOLS

We have collected data using the various intervention tools described below to evaluate this action plan.

1. Feedback: We used different types of feedback: 1) weekly google survey form-based feedback after every lecture, 2) QMPlus-based mid-module feedback, 3) QMPlus-based final module feedback, and 4) alumni feedback.

The following questions were included in the weekly Google survey form-based feedback (Questionnaire):

a) Are you satisfied with the ideas presented in the online session that can be applied to your profession? (Please answer on a scale of 1-5)
b) Is there anything more should say during this online session?
c) Is there anything should remove from this session?

For this feedback, we have utilised the Traffic Light Model, which assisted us in evaluating teaching throughout the course's delivery and improve teaching practice in the future. Next, we used the following three questions for QMPlus-based mid-module feedback:

a) What are the most beneficial aspects of this module?
b) What changes could be made to this module to make it more helpful?
c) Rate the module so far: (1 - Very dissatisfied, 2 - Dissatisfied, 3- Neutral, 4 - Satisfied, 5 - Very Satisfied)

QMPlus-based final module feedback have contained the standard questions as per QMUL norms.

Alumni Feedback: This is a semester B module, which means that most students started work, internships, completing online certificates, or applying for a PhD in May or June. Through the cloud computing module, we have collected their opinions on how to improve their chances of achieving professional success. The questions on the Alumni Feedback form are as follows:

a) Do you believe that the cloud computing module that has been made available to you includes beneficial ideas that may be applied to your professional success? (Please answer on a scale of 1-5)
b) Have you completed online certifications in the most recent cloud computing tools and technologies with good scores?
c) Have you successfully gained employment skills that will be beneficial to you in your future employment?
d) Have you been offered the position, employment, or a research opportunity (PhD)?

2. Formative Assessments: For each topic, we have utilised a QMPlus-based Q/A format, and students must respond to these questions within one week after receiving them. The quizzes we utilised throughout the online session were Mentimeter- or Kahoot-based and used for various objectives, including activating past knowledge and checking students' understanding to determine their level of knowledge, involvement, attendance and engagement. The following two examples (Figure 7 and Figure 8) show the use of Mentimeter or Kahoot-based quizzes for cloud computing module:

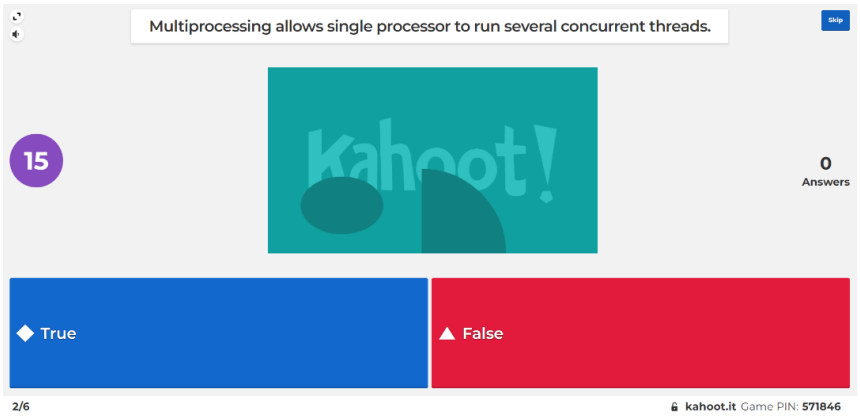

Figure 7: An example shows the use of Kahoot-based quiz

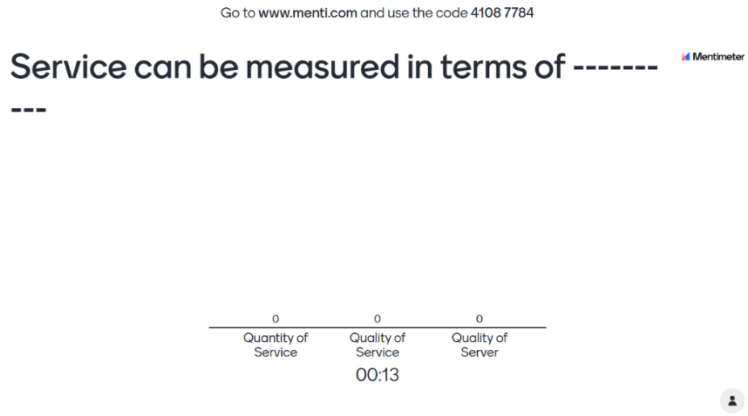

Figure 8: An example shows the use of Mentimeter-based quiz

3. External Observations: We have requested one of our colleagues to act as an external observer for online session and lab. The comments were collected using the usual teaching observation Pro-forma, which we utilised in the second module of Postgraduate Certificate Academic Practice (PGCAP) at QMUL. i.e. Learning and Teaching in the Disciplines (Gill et al., 2023c).

4. Summative Assessments: We have evaluated the students individually (lab quiz after every lab) and in a group (to check their teamwork skills while doing a group project in a team).

5. Reflective Log: When implementing this action plan, we wanted to maintain a reflective log that will provide with the data we needed to enhance teaching practice in the future.

6. VLE report and Analysis: There are a variety of active learning activities that we have deployed on QMplus, including H5P-based videos, Blackboard-based online sessions, Q/A, lab quizzes, and different types of feedback (more details given in the assignment). We used this information to learn more about students' involvement, attendance, and engagement.

7. Interview with Focus Groups: Following the delivery of the module, we have done some interviews with focus groups to learn more about the areas that need to be improved.

8. Give presentations and discussions with colleagues: To showcase our findings inside the school, we have conducted presentations and seminars, as well as engage in discussions with colleagues who are teaching the same module at other institutions such as Imperial College London, University of Manchester and the University of Melbourne. These presentations & discussions have provided us with valuable feedback on this action research, which has helped to improve teaching practice for its sustainable future.

APPENDIX 2: ADDRESSING ETHICAL CONCERNS

What are the risks?

- **Loss of anonymity** ☑ Using a shared platform (such as Google Forms), students forms online groups depending on their preferences and programming skills.
- **Loss of confidentiality** ☑ Every one of the class participants accesses to the participant's data, including both personal and educational information to make groups.
- **Potential victimisation** ☑ For example, a learner can decline to work in a team because of their differing educational backgrounds or cultures.
- **Distress** ☑ Working in a team might cause stress or anxiety.
- **Embarrassment** ☑ Keep an eye out for certain teams or members of specific teams.

How will you reduce these risks?

Gaining the informed consent of participants using:

- **Verbal information provided** ☑ Every lab should begin with an ethical announcement outlining essential aspects, such as everyone accepting responsibility for preserving confidentiality. Every team's performance should be assessed weekly to ensure that they are on track to meet their goal. Individual work or the formation of new teams may be an option for students who are uncomfortable working in teams because of their academic qualifications, ethnicity or religion.
- **Information sheet** ☑ All of the information on ethical challenges, data protection & confidentiality, and fair assignment of responsibilities is contained in this document. As part of the Data Protection and Confidentiality policy (GDPR), the information sheet specified that data records are handled in accordance with this policy. Only members of the team are able to view the details of other group mates as mentioned in BERA Guidelines. Following QMUL's research integrity standards, all individual data is maintained in accordance with the local ethical policy, and all acquired data is safeguarded using credentials (such as username and passwords).
- **Signed consent form** ☑ In order to keep the zone of recognized behaviour intact, adhere to the instructions provided in the information sheet and join a specific group only if the individual has consented to do so.
- **Verbal consent** ☑ All members of the group should get full equality.
- Participants will be informed about their right to withdraw at any time ☑

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We are thankful to faculty members and colleagues who have given their valuable comments to improve the quality of this work. We declare that this work is an updated version of the assignment which has been submitted for the module **"Action (practitioner) Research Design"** in partial fulfilment of the requirements for the award of degree of ***Postgraduate Certificate Academic Practice (PGCAP) – UK Teaching Qualification*** submitted in ***QM Academy*** of Queen Mary University of London, UK is an authentic record of research work carried out by ***Sukhpal Singh Gill*** (***First Author)*** under the

supervision of ***Ana Cabral (Second Author)*** and refers other researcher's work which are duly listed in the reference section. This *Assignment* has been checked using Tutnitin at Queen Mary University of London, UK and submitted assignment has been stored in repository for university record.

REFERENCES

Achuthan, K., & Murali, S. S. (2017). *Virtual lab: an adequate multi-modality learning channel for enhancing students' perception in chemistry*. In Computer Science On-line Conference Springer, Cham, 419-433.

Achuthan, K., Francis, S. P., & Diwakar, S. (2017). Augmented reflective learning and knowledge retention perceived among students in classrooms involving virtual laboratories. *Education and Information Technologies*, 22(6), 2825-2855.

Alves, A. C., Mesquita, D., Moreira, F., & Fernandes, S. (2012). *Teamwork in Project-Based Learning: engineering students' perceptions of strengths and weaknesses*, Third International Symposium on Project Approaches in Engineering Education (PAEE'2011): aligning engineering education with engineering challenges, 1-13.

Amstelveen, R. (2019) Flipping a college mathematics classroom: An action research project. *Education and Information Technologies*, 24, 1337–1350.

Baker, R. S., Clarke-Midura, J., & Ocumpaugh, J. (2016). Towards general models of effective science inquiry in virtual performance assessments. *Journal of Computer Assisted Learning*, 32(3), 267-280.

British Educational Research Association Guidelines (BERA 2018): *BERA Ethical Guidelines for Educational Research*. Available at: https://www.bera.ac.uk/wp-content/uploads/2018/06/BERA-Ethical-Guidelines-for-EducationalResearch_4thEdn_2018.pdf?noredirect=1

Brooman, S. (2011). *Enhancing Student Engagement by Building upon the 'Tectonic Plates' of Legal Education*, Liverpool Law Rev, 32, 109–112

Burrows, A. & Borowczak, M. (2019) Computer science and engineering: utilizing action research and lesson study, *Educational Action Research*, 27:4, 631-646

Carr, F., and S. Kemmis. (1986). *Becoming Critical: Education, Knowledge and Action Research*. Lewes: Falmer Press.

Cavinato, A. G., Hunter, R. A., Ott, L. S., & Robinson, J. K. (2021). Promoting student interaction, engagement, and success in an online environment. *Analytical and Bioanalytical Chemistry*, 413, 1513–1520.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. London: Rutledge Flamer.

Elliott, J. 1991. *Action Research for Educational Change*. Milton Keynes: Open University Press.

García-Peñalvo, F. J., Corell, A., Abella-García, V., & Grande-de-Prado, M. (2021). *Recommendations for Mandatory Online Assessment in Higher Education During the COVID-19 Pandemic*. In Radical Solutions for Education in a Crisis Context, Springer, Singapore, 85-98.

Giannini, G. (1999). 'Drop-in' sessions: information literacy responding to student needs. *Australian Academic & Research Libraries*, 30(3), 212-218.

Geiger, O. G., & Bostow, D. E. (1976). Contingency-managed college instruction: Effects of weekly quizzes on performance on examination. *Psychological Reports*, 39(3), 707-710.

Gerstenhaber, J. A., & Har-El, Y. E. (2021). Virtual biomaterials lab during COVID-19 pandemic. *Biomedical engineering education*, 1(2), 353-358.

Gill, S. S., Naeem, U., Fuller, S. Chen, Y., & Uhlig, S. (2022a). How Covid-19 Changed Computer Science Education, *ITNOW*, 64 (2), Issue 2, 60–61.

Gill, S. S., Fuller, S., Cabral, A., Chen, Y., & Uhlig, S. (2023a). An Operating System Session Plan Towards Social Justice and Intercultural Development in Microteaching for Higher Education, In E. Meletiadou (Eds.), *Handbook of Research on Fostering Social Justice Through Intercultural and Multilingual Communication* (pp. 1-15). IGI Global.

Gill, S. S., Fuller, S., Cabral, A., Chen, Y., & Uhlig, S. (2023b). Curriculum Redesign for Cloud Computing to Enhance Social Justice and Intercultural Development in Higher Education, In E. Meletiadou (Eds.), *Handbook of Research on Fostering Social Justice Through Intercultural and Multilingual Communication*, 44-61. Hershey, PA: IGI Global.

Gill, S. S., Thibodeau, D., Kaur, R., Naeem, U., Stockman, T., (2023c), Reflection on Teaching Observation for Computer Science and Engineering to Design Effective Teaching Resources in Transnational Higher Education, In Morris, G. R., & Li, L. (Eds.), *Handbook of Research on Developments and Future Trends in Transnational Higher Education*, 62-80. Hershey, PA: IGI Global.

Gill, S. S., Xu, M., Ottaviani, C., Patros, P., Bahsoon, R., Shaghaghi, A. & Uhlig, S. (2022b). AI for next generation computing: Emerging trends and future directions. *Internet of Things*, 19, 100514.

Glassman, M. (2020) The internet as a context for participatory action research. *Education and Information Technologies*, 25, 1891–191.

Gokbulut, B. (2020). The effect of Mentimeter and Kahoot applications on university students'-learning. World Journal on Educational Technology: *Current Issues*, 12(2), 107-116.

Gunawan, G., Harjono, A., Sahidu, H., & Herayanti, L. (2017). Virtual laboratory to improve students' problem-solving skills on electricity concept. *Journal Pendidikan IPA Indonesia*, 6(2), 257-264.

Hager, P., Sleet, R., & Kaye, M. (1994). The relation between critical thinking abilities and student study strategies. *Higher Education Research and Development*, 13(2), 179-188.

Hanna, W. (2007). The new Bloom's taxonomy: Implications for music education. *Arts Education Policy Review*, 108(4), 7-16.

HEA (2015). *Framework for student engagement through partnership*. Available: https://www.heacademy.ac.uk/sites/default/files/downloads/studentenagagement-through-partnership-new.pdf (Accessed November 2021)

Hoegl, M., & Parboteeah, K. P. (2007). Creativity in innovative projects: How teamwork matters. *Journal of engineering and technology management*, 24(1-2), 148-166.

Holtzman, D. M., & Kraft, E. M. (2011). *A comparison of qualitative feedback from alumni and employers with a national study for assessment of business curricula*. In American Institute of Higher Education 6th International Conference Proceedings, 4, 173-179.

Homanová, Z., & Havlásková, T. (2019). H5P interactive didactic tools in education. *In 11th International Conference on Education and New Learning Technologies*. 1-6.

Hughes, M., Salamonson, Y., & Metcalfe, L. (2020). Student engagement using multiple-attempt 'Weekly Participation Task'quizzes with undergraduate nursing students. *Nurse Education in Practice*, 46, 22-36.

Isaias, P. & Issa, T. (2014) Promoting communication skills for information systems students in Australian and Portuguese higher education: Action research study. *Education and Information Technologies*,19, 841–861.

Junco, R. (2012). The relationship between frequency of Facebook use, participation in Facebook activities, and student engagement. *Computers & Education*, 58(1), 162-171.

Kashefi, H., Ismail, Z., & Yusof, Y. M. (2012). The impact of blended learning on communication skills and teamwork of engineering students in multivariable calculus. *Procedia-Social and Behavioral Sciences*, 56, 341-347.

Kapilan, N., Vidhya, P., & Gao, X. Z. (2021). Virtual laboratory: A boon to the mechanical engineering education during covid-19 pandemic. *Higher Education for the Future*, 8(1), 31-46.

Kemmis, S., & McTaggart, R. (1988). *The action research planner*. Victoria. Australia: Deakin University.

Lambirth, A., and A. Cabral., McDonald, R. (2019) Transformational professional development: (re)claiming agency and change (in the margins). *Teacher Development*, 23(3), 387-405

Lambirth, A., and A. Cabral. (2017) Issues of Agency, Discipline and Criticality: An Interplay of Challenges Involved in Teachers Engaging in Research in a Performative School Context. *Educational Action Research* 25 (4): 650–666.

Lewin, K. (1946) Action research and minority problems. *Journal of Social Issues*. 2 (4), 4–46.

Luse, A., & Rursch, J. (2021). Using a virtual lab network testbed to facilitate real-world hands-on learning in a networking course. *British Journal of Educational Technology*, 52(3), 1244-1261.

Naeem, U., Bosman, L., & Gill, S. S. (2022, March). *Teaching and Facilitating an Online Learning Environment for a Web Programming Module*. In 2022 IEEE Global Engineering Education Conference (EDUCON) (pp. 769-774). IEEE.

Pappas, E., Pierrakos, O., & Nagel, R. (2013). Using Bloom's Taxonomy to teach sustainability in multiple contexts. *Journal of Cleaner Production*, 48, 54-64.

Pazos, P., Cima, F., Kidd, J., Ringleb, S., Ayala, O., Gutierrez, K., & Kaipa, K. (2020). Enhancing Teamwork Skills Through an Engineering Service-learning Collaboration. In 2020 ASEE Virtual Annual Conference Content Access, Virtual Online, 1-6.

Qi, W. (2012). On the New Development of the Framework of Higher Education Qualifications in England, Wales and Northern Ireland (FHEQ) and Its Enlightenment. *China Higher Education Research*, 3, 1-20.

QMUL (2009). *The Queen Mary Statement of Graduate Attributes*. Available at http://www.arcs.qmul.ac.uk/media/arcs/docs/quality-assurance/QMULGraduate-Attributes.pdf (Accessed: November 2021)

QMUL ethical procedures (2022): http://www.arcs.qmul.ac.uk/research-degrees/research-degree-students/ethics/

Quality Assurance agency (QAA), (2018). *The UK quality code for higher education*, https://www.qaa.ac.uk/en/quality-code, last accessed 02/10/2021.

Sancho, P., Corral, R., Rivas, T., González, M. J., Chordi, A., & Tejedor, C. (2006). A blended learning experience for teaching microbiology. *American Journal of Pharmaceutical Education*, 70(5), 1-16.

Singhal, R., Kumar, A.12, Singh, H., Fuller, S., & Gill, S. S. (2021). Digital device-based active learning approach using virtual community classroom during the COVID-19 pandemic. *Computer Applications in Engineering Education*, 29(5), 1007-1033.

Sosniak, L. A. (1994). *Bloom's taxonomy*. L. W. Anderson (Ed.). Chicago, IL: Univ. Chicago Press.

Stenhouse, L. (1975) *Introduction to curriculum research and development*. London: Heinemann Educational.

Yusuf, I., & Widyaningsih, S. W. (2020). Implementing E-Learning-Based Virtual Laboratory Media to Students' Metacognitive Skills. *International Journal of Emerging Technologies in Learning*, 15(5), 1-12.

UK GDPR (2018). *The General Data Protection Regulation (GDPR) Guidance for members*. Available at: https://www.local.gov.uk/sites/default/files/documents/The%2BGeneral%2BProtection%2BData%2BRegulation%2B%28GDPR%29%2B-%2BGuidance%2Bfor%2BMembers.pdf (Accessed: November 2021)

Zeni, J. (1998). A guide to ethical issues and action research. *Educational action research*, 6(1), 9-19.

Zuber-Skerritt, O. (Ed.). (2021). *Action research for change and development*. Routledge.

KEY TERMS AND DEFINITIONS

Learner: This word is used interchangeably with "student" and "participant".

Cloud Computing: Pay-as-you-go IT resources are made available on-demand over the Internet.

Think-pair-share: Students work together to solve an issue or answer a question on a text they've been assigned.

Formative Assessment: Monitor student learning to offer feedback that may be utilised by instructors to enhance their instruction as well as the student's learning, the purpose of formative assessment.

Sustainable Learning: With this approach to life and education students, teachers, schools as well as their surrounding communities may work together to create a more just, sustainable and equal society.

Action Research: Instructors uses this methodology to conduct investigations into their own professional practises to learn more about how students learn and how to better educate them..

QMPLUS: It is the online learning environment (OLE) used across the university (Queen Mary University of London) and is based on Moodle.

ADDITIONAL READING

Marinescu, D. C. (2022). *Cloud computing: theory and practice*. Morgan Kaufmann.

Meletiadou, E. (2021a). Exploring the impact of peer assessment on EFL students' writing performance. *IAFOR Journal of Education, 9*(3), 77-95.

Meletiadou, E. (2021b). Opening Pandora's box: How does peer assessment affect EFL students' writing quality? *Languages, 6*(3), 115.

Meletiadou, E. (2013). EFL learners' attitudes towards peer assessment, teacher assessment and the process writing' (Vol. M.A.). In D. Tsagari (Ed.) *Language Testing and Evaluation Series, 28* (pp. 312-330). Frankfurt am Main: Peter Lang GmbH.

Meletiadou, E. (2012). The impact of training adolescent EFL learners on their perceptions of peer assessment of writing. *RPLTL, 3*(1), 240-251.

Meletiadou, E. (2011). Peer assessment of writing in secondary education: Its impact on learners' performance and attitudes. *M.A. in Applied Linguistics*, University of Cyprus, Nicosia.

Meletiadou, E., & Tsagari, D. (2016). The washback effect of peer assessment on adolescent EFL learners in Cyprus. In D. Tsagari (Ed.) *Classroom-based assessment in L2 contexts*. Cambridge Scholars Publishing.

Meletiadou, E., & Tsagari, D. (2014). An exploration of the reliability and validity of peer assessment of writing in secondary education. In D. Tsagari (Ed.) *Major trends in theoretical and applied linguistics 3* (pp. 235-250). De Gruyter Open Poland.

Meletiadou, E., & Tsagari, D. (2012). Investigating the attitudes of adolescent EFL learners towards peer assessment of writing. In D. Tsagari (Ed.) *Research on English as a foreign language in Cyprus Volume II* (pp. 225-245). University of Nicosia Press.

Wang, L., Ranjan, R., Chen, J., & Benatallah, B. (Eds.). (2017). Cloud computing: methodology, systems, and applications. *CRC Press*.

Meletiadou, E. (Ed.). (2023). Handbook of Research on Fostering Social Justice Through Intercultural and Multilingual Communication. *IGI Global*.