



Title	An Investigation of Interactive Learning Environments with Cloud Computing in Higher Education: Institution-Level Adoption and the Effects on Students' Learning Outcomes
Author(s)	Soto Campusano, David Enmanuel
Citation	大阪大学, 2025, 博士論文
Version Type	
URL	https://hdl.handle.net/11094/101761
rights	
Note	やむを得ない事由があると学位審査研究科が承認したため、全文に代えてその内容の要約を公開しています。全文のご利用をご希望の場合は、 ＜a href="https://www.library.osaka-u.ac.jp/thesis/#closed"> 大阪大学の博士論文について をご参照ください。

The University of Osaka Institutional Knowledge Archive : OUKA

<https://ir.library.osaka-u.ac.jp/>

The University of Osaka

Abstract of Thesis

Name (David Enmanuel Soto Campusano)	
Title	An Investigation of Interactive Learning Environments with Cloud Computing in Higher Education: Institution-Level Adoption and the Effects on Students' Learning Outcomes (高等教育におけるクラウドコンピューティングを用いたインタラクティブ学習環境の調査：機関レベルでの導入と学生の学習成果への影響)
Abstract of Thesis Interactive Learning Environments (ILEs) are software-based systems that support interactive teaching and learning in education. ILEs promote interactions through elements such as dynamic multimedia, dashboards, buttons, and bars objects to execute actions within the environment, live blocks of text and codes to run programmable actions, and other advanced features including access to virtualized devices, virtual reality, and augmented reality tools, and collaboration spaces for its users. Other novel developing technologies such as Generative AI (GenAI) are also being integrated alongside ILEs, enabling students to use prompts and inputs to generate text, images, and video responses, and delve deeper into the learning concepts. Through all the previous functionalities, rather than focusing on static contents and memorization methods, ILEs encourage students to engage with the interactive content and tools, while supported by teachers and instructors, contributing to a better learning experience. In contrast with traditional lecture settings, where the instructions and flow of the class are regulated by the teachers focusing on the use of static learning materials, ILEs provide ways to encourage engagement and motivation of students, resulting in a higher level of interaction with lesson's content and learning materials, while also promoting active participation through its interactivity features. Additionally, other functionalities such as the immediate feedback from automated assessment and consultation tools and the adaptability of the systems to the learning paces and styles of the students allow for personalized learning experiences. This then can translate into better knowledge assimilation and understanding for the students. Despite these benefits, ILEs have not been widespread, and there has been limited use by teachers and instructors during their classes due to several factors. One of the major issues is the lack of reliable and supporting IT computing infrastructure, such as the ones provided by Cloud Computing (CC). However, this situation was changed by the COVID-19 pandemic, forcing Higher Education Institutions (HEIs) to migrate and maintain their online learning environments in the cloud to keep the continuity of their academic programs during lockdown measures and remote learning policies. These rapid changes also posed new challenges, as many HEIs were not initially prepared to make such transitions, finding in the way obstacles such as reliable Internet access for students and teachers, scalability and performance of the systems, budget constraints, and lack of technical expertise on CC technologies. Additionally, from a pedagogical perspective, the effective use of ILEs, the instructional design for lesson contents, and the assessment of student's learning outcomes in cloud-based environments also present new barriers for HEIs. In motivation to the previous challenges, this dissertation aims to understand the adoption and barriers of ILEs in the cloud within HEIs, and assess the learning experience and learning outcomes of students through the implementation of interactive lessons using an ILE, ultimately providing insights needed for their effective adoption in HEIs in the post-COVID-19 era.	

This research consists of a two-step proposal. The first step is a pre-survey about the adoption and barriers of ILEs in the cloud in HEIs. We investigated the institution-level CC adoption, including the adoption of ILEs, through the Technology-Organization-Environment (TOE) framework, a widely known theoretical model specialized in the study of how organizations adopt new technologies and innovations such as the cloud. This was done to understand the current status of CC adoption after COVID-19. The surveys were conducted in two countries, Dominican Republic (18 HEIs) and Japan (97 HEIs) as they provide different cultural, educational, and levels of technological adoption perspectives.

The survey results from the Dominican Republic and Japan showed a high level of CC adoption in HEIs in both countries. However, despite the influence of COVID-19 forcing HEIs to transition their learning environments to the cloud, insights revealed noticeable low adoption rates for cloud-hosted ILEs and virtual laboratories compared to other critical educational IT services. Approximately 40% of HEIs in both countries reported no use or implementation of ILEs or virtual laboratories. Among the remaining institutions, 30% in Japan and 11% in the Dominican Republic stated they had no plans to host them in the cloud. This underutilization suggests potential barriers and resistance within HEIs that need to be understood and addressed to fully leverage the benefits of CC technologies for interactive and remote learning. These barriers included financial constraints and confidentiality concerns reported by Dominican HEIs. Meanwhile, Japanese HEIs presented data security concerns, budget execution constraints within the Pay-as-you-go model of the cloud, lack of expertise, and the persistence of traditional "on-site" computing doctrines still maintained by some institutions. Addressing these issues is crucial to maximizing the potential of cloud-based solutions and encouraging the use of blended learning environments that support tools such as ILEs to enhance learning experiences alongside traditional lecture settings.

The second step of the research proposal is to address the previously reported gaps in the low adoption of cloud-based ILEs. For this, we subsequently discuss the opportunities, challenges, and outcomes of using ILEs supported by CC through educational practice research using an ILE integrated with GenAI. The proposed ILE consists of three elements: (1) an on-demand virtual environment presented interactively via a web browser; (2) a plug-in providing a chat-box powered by GenAI; and (3) a Learning Management System (LMS) for content delivery.

An experiment was designed as a series of mock lessons to simulate online self-study and interactive educational practice in computer networking topics. This was the suggested topic as it is one of the fundamental blocks in the IT learning curriculum. Lessons were delivered to the students through the ILE, encouraging them to utilize both the system's interactive components and the support of the GenAI tool to enhance their understanding of the topics. Some interactive components included virtual network devices, remote terminal connections, and buttons to execute commands to configure network settings and troubleshoot devices automatically. During the experiment, the students were separated into two groups according to the use of the GenAI tool to assess for any significant difference between their learning outcomes and learning experiences. Students used the GenAI as an aiding tool by directly asking for details of particular concepts and providing instructional prompts about the context of the network diagrams and configurations of the networking devices for debugging and troubleshooting. For the learning evaluation, pre-tests and post-tests based on the contents of the lessons were used to assess the learning outcomes of the students, while comprehensive surveys were used to evaluate their views on the experiences of using the ILE and the GenAI tool.

The main findings from the experiment revealed a positive impact on the learning outcomes of the students. This was demonstrated through knowledge assessments, where students had an average

Normalized Learning Gain between 57.6% and 63.5% when comparing pre/post-test scores. Additionally, students scored an average between 60% and 100% on all quizzes between lectures, indicating that they were able to comprehend the underlying concepts and basic objectives of each lesson. In terms of the general assessment of the ILE, students reported positive self-evaluations regarding the achievements of the learning objectives of the experiment. Overall, the students expressed that they were able to achieve the expected learning outcomes from the lessons and that the difficulty, amount of learning content, and explanations of teaching materials were appropriate. Regarding the experience with the ILE and the interactivity features, the students stated that the systems were user-friendly, provided an authentic remote terminal experience similar to a real-world environment, and enhanced the comprehension of concepts when compared to static learning materials.

While no significant evidence was found to indicate that additionally integrating GenAI into ILEs results in better comprehension or scores, students in the ChatGPT group reported higher satisfaction in learning outcomes, lesson difficulty, and overall experience. However, some students showed mixed views regarding the experience and use of the GenAI tool. In particular, concerns were expressed on the usefulness of the GenAI in supporting the responses to questions in lesson exercises, the timely assistance from queries, and the interface of the chat-box. Nonetheless, they agree in general that the answers provided by the GenAI were easy to understand, and would recommend its use to other students for learning purposes, and conveyed that they would like teachers to use more GenAI tools during lectures.

The originality and novelty of this dissertation are reflected in three key aspects. First, it examines the intersection of ILEs, GenAI, and CC within HEIs. While these components have been individually studied, their combined impact on educational outcomes is relatively unexplored. Secondly, by evaluating the effectiveness of ILEs augmented with GenAI in computer networking education, it provides insights into how emerging technologies can enhance learning outcomes in technical disciplines. Additionally, the comparative analysis of CC adoption and educational practices between the Dominican Republic and Japan introduces a cross-cultural perspective, highlighting the benefits and challenges faced by HEIs in different regions, while considering recent factors such as COVID-19. This dissertation contributes through its interdisciplinary approach, by examining innovative applications of technology-enhanced learning methods and the exploration of global educational trends and practices.

論文審査の結果の要旨及び担当者

氏 名 (David Enmanuel SOTO CAMPUSANO)			
	(職)	氏 名	
論文審査担当者	主 査	教授	浦西 友樹
	副 査	教授	土屋 達弘
	副 査	教授	長瀧 寛之
	副 査	准教授	白井 詩沙香

論文審査の結果の要旨

本学位論文は、高等教育機関におけるクラウドホスト型のインタラクティブな学習環境（Interactive Learning Environments, ILEs）の導入に係る障壁を明らかにすること、生成AIを活用したILEsの効果について学習成果と学習体験の観点から評価することを目的としている。双方向学習を支援するILEsは、インタラクティブなコンテンツやツールを通じて、学習者のモチベーションや学習意欲を促す利点があると言われている。このような利点がある一方、授業へのILEsの導入は限られており、主要な原因のひとつに情報基盤に関する課題が挙げられる。

本学位論文では、ILEsの普及に向けて、高等教育機関におけるクラウドコンピューティング（Cloud Computing, CC）の導入と障壁について論じている。さらに、近年様々な分野で導入が検討されている生成AIに着目し、生成AIを統合したILEsが学習者に与える影響について、実際の授業を通じて調査を行ない、その研究成果をまとめている。主要な研究成果は以下の通りである。

1. 高等教育機関におけるCCの導入と障壁に関する調査を、文化的、教育的、技術導入の観点において異なる視点を提供できるドミニカ共和国（18の高等教育機関）と日本（97の高等教育機関）の2か国で実施した。調査の結果、両国の高等教育機関におけるCCの導入率は高い一方で、高等教育機関が学習環境をクラウドに移行せざるを得ない状況を招いた新型コロナウイルス感染症（COVID-19）パンデミックの影響があったにもかかわらず、クラウドホスト型のILEsやバーチャルラボの導入率は、他の重要な教育用ITサービスと比較して著しく低いことを確認している。その主要な要因として、ドミニカ共和国の調査からは財政的な制約や機密保持に関する懸念、日本の調査からは、データセキュリティへの懸念、クラウドの従量制課金モデルにおける予算執行の制約、専門知識の不足などの障壁を確認している。
2. 生成AIを活用したILEsの効果について明らかにするために、情報ネットワークの授業を対象に、生成AIを統合したILEsが学習者の学習成果と学習体験に与える影響を調査している。実験協力者をILEsに生成AIを統合した環境を利用する群と統合しない環境を利用する群に分け、同条件の授業を受講してもらった結果、学習成果については両群に差が見られなかったが、生成AIを統合したILEsを利用した群の学習体験に関するアンケートでは、高い満足度が得られたことを報告している。一部の実験協力者より、有用性について懸念が示されたが、生成AIが提供する回答は理解しやすく、学習目的で他の学生にもその使用を推奨したいという意見は概ね一致しており、講義中に教師が生成AIツールをより多く使用することを望んでいることを確認している。

以上のように、本学位論文における研究成果は、ILEsの普及に向けて、高等教育機関における組織的な導入、ILEsの設計、授業デザイン等に多くの示唆と洞察を与えるものであり、情報科学に寄与するところが大きい。よって、本論文は博士（情報科学）の学位論文として価値あるものと認める。