Proceedings of the 21st ICSMGE, Vienna, Austria, 14 – 19 June 2026. Pistrol, Adam & Schweiger (eds.)
Published by: ÖGG, Austrian Society for Geomechanics, Salzburg, Austria, ISBN 978-3-9503898-4-5
https://doi.org/10.53243/ICSMGE2026-2183

Challenges and Opportunities of Virtual Education in Geotechnical Roads: A Case Study of graduate course in Road Infrastructure (2023–2024 Editions)

Andres Bernardo Vargas Estrada, Christian Boris Camacho Peña, Luis Fernando Zambrana Juchani
UNIVERSIDAD MAYOR DE SAN SIMON, Bolivia, Plurinational State of; abvargas13@gmail.com

ABSTRACT: Virtual education in geotechnical engineering presents challenges due to the practical nature of the discipline, particularly in modules that require laboratory and field activities. This study analyzes the implementation of virtual teaching and assessment strategies in the Road Geotechnics module of the Graduate Diploma in Road Infrastructure at the Universidad Mayor de San Simón during the 5th and 6th editions (2023–2024). The objective was to evaluate students' perceptions of the competencies acquired and the contribution of digital platforms such as Google Classroom, Zoom, and AI-generated session highlights. A mixed-methods approach was applied, combining student questionnaires and semi-structured interviews. The results indicate that virtual education improves accessibility and supports theoretical learning through multimedia and asynchronous tools, but presents limitations in practical skill development. The integration of collaborative activities, real-case analyses, and AI-generated highlights helped reinforce key concepts. These findings underscore the need for blended educational models that balance digital flexibility with in-person practical experiences to ensure comprehensive competency development in geotechnical engineering.

KEYWORDS: Virtual education, geotechnical roads, degree modalities.

1 INTRODUCTION

In higher education, constant evolution and adaptation are essential to ensure effective and relevant training processes. Within this context, the present study seeks to critically examine the effectiveness of assessment instruments and students' perceptions in the Road Geotechnics module of the Diploma in Road Infrastructure at the Universidad Mayor de San Simón. The need to investigate these aspects stems from the growing demand for continuous evaluation and improvement of assessment practices, ensuring their alignment with labor market expectations and the evolving needs of society.

This leads to the central research question: How does virtual education, supported by digital platforms and assessment tools, influence the development of technical competencies and student perceptions in postgraduate geotechnical engineering training? Accordingly, the study aims to evaluate the effectiveness of virtual teaching and assessment strategies implemented in the Road Geotechnics module of the Graduate Diploma in Road Infrastructure, with particular emphasis on students' perceptions of the competencies acquired. To achieve this objective, the research seeks to: (i) identify and characterize the assessment instruments and digital tools used within the virtual learning environment; (ii) examine students' perceptions regarding the applicability of the competencies acquired to professional geotechnical practice; and (iii) analyze the alignment between virtual assessment instruments, digital learning platforms, and students' perceptions of the practical relevance and effectiveness of the learning process.

The overarching goal of this postgraduate training program is to equip participants with both technical-scientific knowledge and professional skills, enabling them to effectively address the technical demands of civil engineering projects. This comprehensive approach is reflected in the program's structure, which comprises seven consecutive modules. The final module is dedicated to the degree project, requiring participants to apply and consolidate the knowledge acquired throughout the program.

The diploma program benefits not only practicing professionals in civil engineering but also students who have completed their undergraduate coursework. Since 2017, the Universidad Mayor de San Simón has implemented a dual-degree pathway that allows students who have finished their undergraduate studies to pursue a diploma program in lieu of a traditional thesis or comprehensive examination. Upon successful completion, these students are awarded both a bachelor's and a postgraduate diploma, offering a flexible alternative for obtaining academic qualifications (Opinión, 2017).

The student body in this diploma program is notably diverse, encompassing experienced professionals as well as recent graduates who have only just completed their academic programs. This heterogeneity raises important questions about the effectiveness of the educational processes currently in place.

2 LITERATURE REVIEW

2.1 *Evaluation in Higher Education*

Reyes and Díaz (2020) point out that the European Higher Education Area (EHEA) states "…the primary objective of assessment is to promote student learning…".

Assessment in the field of higher education stands as a fundamental pillar whose main purpose lies in measuring learning and the achievement of competencies by students. This process, multidisciplinary in nature, encompasses a diverse set of techniques and strategies designed to accurately and comprehensively capture students' academic progress and their ability to apply knowledge (Hernández Falcón, Vargas Jiménez, & Alumiñas Rivero, 2020).

Assessment is not limited solely to the quantification of results; it also plays an essential role in diagnosis and feedback. By employing varied methods—from traditional tests and examinations to projects and authentic assessments—the aim is not only to measure the level of knowledge attained but also to understand the depth of comprehension, critical analysis skills, and the ability to apply such knowledge in practical and real-world contexts. Educational assessment is a continuous and personalized process within the teaching–learning system that enables educators to determine the level of knowledge, skills, and values achieved by students (Ley Leyva & Espinoza Freire, 2021). Likewise, it allows for the evaluation of whether the objectives, methods, organization, and teaching strategies of the program in question were appropriate.

In this context, the effectiveness of teaching performance is profoundly influenced by the disposition and skills of the educators. It is not only a matter of assessing students' knowledge during classes, but also of making informed decisions that effectively drive the learning process. Teacher training in the field of formative assessment, in this regard,

emerges as a crucial tool. It provides educators with the skills and perspectives necessary to design and implement assessments that not only measure but also guide and foster the holistic development of students throughout their academic trajectory (Bizarro, Sucari, & Quispe-Coaquira, 2019).

2.2 *Evaluation instruments*

There is often a persistent confusion between the terms "assessment means", "assessment techniques", and "assessment instruments" or "assessment tools." These concepts are frequently intertwined, leading to a lack of clarity regarding their differences and scope. However, Hamondi, López Pastor, and López Pastor (2015) have provided a practical explanation, concluding that it is challenging to discern any significant difference between the concepts of "means," "techniques," and "instruments" of assessment. For practical purposes, an approach will be adopted in which these terms are considered similarly, in line with the aforementioned authors.

In practice, the dividing line between these concepts often becomes blurred due to their inherent interconnectedness. Adopting a unified approach, as suggested by the authors, simplifies the understanding and application of these elements in the evaluative context. It is essential to recognize that, regardless of the terminology used, the effectiveness of the assessment process lies in the careful selection and application of the means, techniques, and instruments that best fit the specific objectives of the evaluation.

This conceptual overlap can be attributed, in part, to the interdependent nature of these elements within the assessment process. Assessment means encompass the various approaches and strategies used to gather information about the performance or achievements of those being assessed. Assessment techniques, on the other hand, refer to the specific methods used within these means to collect data, while assessment instruments are understood as the concrete tools or forms used to carry out the selected assessment techniques.

3 METHODOLOGY

The methodological approach adopted in this study corresponds to a mixed-methods design, integrating both quantitative and qualitative techniques to evaluate the effectiveness of virtual assessment instruments and digital learning tools in relation to students' perceptions and competency development. The quantitative component involved the analysis of structured questionnaires administered to students, allowing for the identification of trends related to competency acquisition, learning satisfaction, and the perceived connection between course content and professional practice.

From a qualitative perspective, the study seeks to investigate, describe, and thoroughly understand the perceptions and viewpoints of the participants involved. This qualitative approach is oriented toward an in-depth exploration and detailed understanding of the experiences, opinions, and perspectives of the subjects, based on semi-structured interviews with students and the course instructor (Hernández Sampieri, Méndez Valencia, Mendoza Torrez, & Cuevas Romo). This integration of methods enables a holistic understanding of the phenomenon under investigation.

3.1 *Population and Sample*

This section describes the population involved in the study, consisting of students and instructors from the 5th and 6th editions of the Diploma in Road Infrastructure.

The population includes 29 students enrolled in the 5th edition of the diploma program, aged between 23 and 44 years, of whom 5 are graduates and 24 are undergraduate students pursuing the degree completion modality. In the 6th edition, there are 29 students aged between 23 and 37 years, including 2 graduates.

The sample comprises the entire population, with a total of 58 students from both programs. A questionnaire was administered to all students, and in-depth interviews were conducted with two of them. Additionally, the instructor was interviewed. All interviews were recorded.

The population was contacted through a Google Form for the completion of the questionnaire, and the interviews were carried out via the Zoom platform.

Questionnaires and interviews were applied, as presented in the following subsections. These techniques were implemented with the aim of obtaining accurate information in a digital format to facilitate data processing.

Interviews were conducted with both instructors and students. The interview tool was developed based on the instrument used by Céspedes López (*Continuous assessment techniques and instruments that verify critical analysis in students of Financial Engineering at UCB, Cochabamba campus*, 2022). This tool had already been used and validated in the referenced study. The guide employed in this research is presented below.

4 RESULTS

4.1 *Instructor Interview*

MACP, the instructor of the Road Geotechnics module, had previously participated as a lecturer in the diploma program in another subject; however, this was his first time teaching this particular module. The assessment process was planned in multiple evaluations due to the extensive content that needed to be covered during the module. Additionally, he incorporated exercise-solving presentations into his classes as part of the learning and assessment process.

The instructor rated the competencies acquired by the participants between 7 and 8 points. He noted that in-class participation was very limited; however, the use of presentations encouraged greater student engagement. He identified three distinct groups among the diploma participants: the first group consisted of students with already consolidated knowledge in the subject, which may explain their lack of participation; the second group showed little interest in the module; and the third group was highly committed and stood out academically.

The interviewee emphasized that the labor market requires professionals in the field to possess both solid theoretical knowledge and professional practice experience. He believes that full acquisition of the targeted competencies could be achieved through a greater number of laboratory-based practical sessions and continuous reading of professional materials. Although the module does not have access to a laboratory for practical exercises, the instructor makes use of alternative strategies to ensure that participants understand how laboratory tests related to the subject are carried out.

4.2 *Students Interview*

One male student, enrolled in the Diploma in Road Infrastructure under the degree completion modality, indicated that he perceived the module's planning as different from that of undergraduate courses, with a stronger focus on presentations. He rated the module 6 out of 10.

V.R.A.T., a civil engineer graduated from the Civil Engineering program at UMSS, rated the competencies acquired during the module with a score of 6 out of 10. She stated that the perception of competencies could be improved

through the inclusion of more case studies in class, the sharing of professional experiences, enhancements in oral communication skills, and better planning of class schedules and distribution of teaching materials.

4.3 *Student Questionnaires*

Questionnaires were administered to all students enrolled in the 5th and 6th editions of the Diploma in Road Infrastructure. The purpose was to gather their perceptions regarding the effectiveness of the assessment instruments, the teaching methods applied, and the competencies acquired throughout the Road Geotechnics module. The responses provided quantitative data for statistical analysis, complemented by qualitative comments to capture additional insights.

For this study, we will focus on three questions asked in both editions of the diploma program and will explore a new tool: the highlights generated with the assistance of Zoom's AI feature. The questions are as follows:

- How would you rate the competencies acquired in this module?

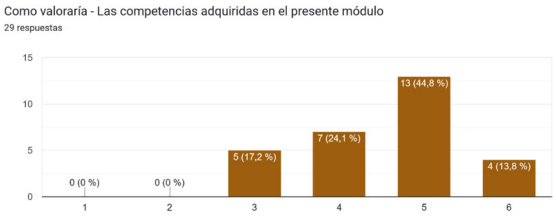

Figure 1. First question 5th edition

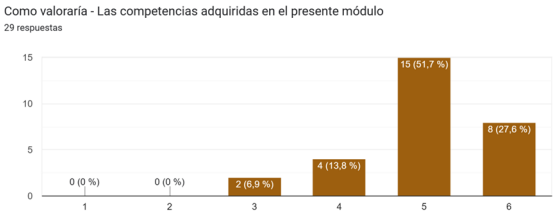

Figure 2. First question 6th edition

- How would you rate the connection between the module content and professional practice?

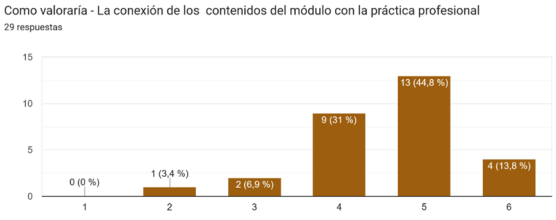

Figure 3. Second question 5th edition

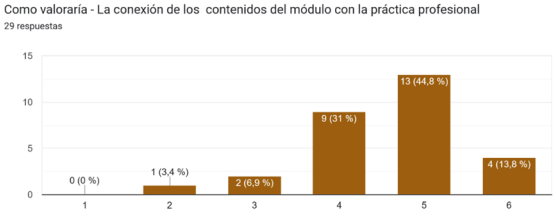

Figure 4. Second question 6th edition

- How would you rate your personal satisfaction after completing the module?

Figure 5. Third question 5th edition

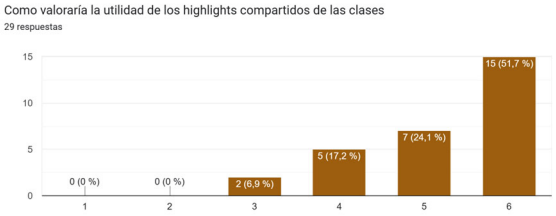

Figure 6. Third question 6th edition

- How would you rate the usefulness of the class highlights that were shared?

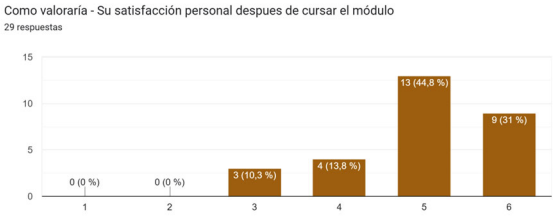

Figure 7. Fourth question 6th edition

5 DISCUSSION

The analysis of responses to the four evaluation questions revealed consistent trends across both editions of the diploma program. Students rated the competencies acquired in the Road Geotechnics module with an average score of 4.6/5, indicating a generally positive perception of learning outcomes, although with acknowledged room for improvement. Similarly, the connection between module content and professional practice received an identical average rating of 4.6/5, suggesting that while most participants recognized the practical relevance of the knowledge gained, some perceived a gap between theoretical instruction and its direct application in real-world geotechnical contexts.

Personal satisfaction after completing the module also averaged 4.6/5, reflecting a balanced appreciation of the overall learning experience. Nevertheless, qualitative feedback from both students and the instructor highlighted the need to enhance engagement and practical exposure, particularly in areas traditionally supported by laboratory testing and fieldwork. These findings reinforce existing concerns in engineering education regarding the limitations of fully virtual modalities for developing hands-on competencies.

A distinctive contribution of this study was the incorporation of Zoom's AI-generated highlights as a pedagogical support tool. The usefulness of these highlights, rated between 5 and 6 by 75.8% of respondents, was widely

recognized as a valuable resource for asynchronously reviewing class content and consolidating understanding. Students emphasized the efficiency of this feature, as it allowed them to revisit key concepts without the need to watch complete recorded sessions, an aspect particularly relevant in postgraduate programs with working professionals. However, qualitative feedback also indicated that the pedagogical value of AI-generated highlights could be enhanced through better integration with course materials, such as the inclusion of explanatory notes or direct links to specific theoretical or applied topics.

Overall, the findings suggest that while virtual education effectively supports theoretical learning and competency development, its impact can be further strengthened by improving the alignment between assessment instruments, digital tools, and practical learning strategies.

6 CONCLUSIONS

The findings of this study highlight both the strengths and limitations of implementing virtual education in the Road Geotechnics module of the Graduate Diploma in Road Infrastructure. Students consistently reported positive perceptions regarding the competencies acquired, the connection between course content and professional practice, and overall satisfaction, all of which achieved average ratings of 4.6 out of 5 across both program editions. These results indicate that virtual education can effectively support theoretical learning and competency development at the postgraduate level.

The integration of Zoom's AI-generated highlights emerged as a valuable pedagogical innovation, receiving favorable evaluations as an efficient tool for reviewing and reinforcing key concepts. By enabling students to revisit essential content without viewing entire recorded sessions, this feature enhanced accessibility and supported learning consolidation in a virtual environment.

Despite these strengths, the study identified clear areas for improvement. Both instructors and students emphasized the need to incorporate additional practical components—such as laboratory activities, fieldwork, and real-case analyses—to better bridge the gap between theoretical instruction and professional geotechnical practice. Improvements in course planning, organization of teaching materials, and opportunities for developing oral communication skills were also identified as relevant factors for enhancing learning outcomes.

This study is limited to the specific institutional context of the Universidad Mayor de San Simón and to the 5th and 6th editions of the program; therefore, the findings may not be directly generalizable to other academic settings. Future research should examine the applicability of these results in different institutional contexts, assess the long-term impact of AI-assisted learning tools, and explore effective strategies for integrating virtual education with hands-on training.

A relevant limitation of this study is the restricted number of qualitative interviews conducted. Although the interviews with selected students and the course instructor provided valuable insights into perceptions, experiences, and challenges associated with virtual education, the limited number of participants may not fully capture the diversity of viewpoints within the student population. Consequently, the qualitative findings should be interpreted as exploratory rather than representative. Future studies would benefit from incorporating a larger and more diverse interview sample to strengthen the depth and robustness of qualitative analysis and to further validate the observed trends.

Overall, while virtual education in geotechnical engineering presents inherent challenges—particularly in replicating practical experiences—it also offers significant opportunities to innovate teaching practices and expand access to specialized training. A blended learning model that combines virtual instruction with targeted in-person practical activities is recommended as an effective approach for achieving comprehensive competency development in geotechnical engineering education.

7 ACKNOWLEDGEMENTS

We gratefully acknowledge the support of the Universidad Mayor de San Simón and the Graduate Diploma in Road Infrastructure, as well as the participation of the students and instructors who contributed to this study. Special thanks are extended to the academic coordination team for facilitating access to institutional resources.

Appreciation is further extended to the Universidad Católica Boliviana "San Pablo" for its academic guidance and for introducing the educational perspective that enriched the pedagogical approach of this research.

8 REFERENCES

Bizarro, W., Sucari, W., & Quispe-Coaquira, A. (2019). Evaluación formativa en el marco del enfoque por competencias. Revista Innova Educación, 17.

Cespedes López, J. B. (2022). Técnicas e instrumentos de evaluación continua que verifican el análisis crítico en los estudiantes de Ingeniería Financiera de la UCB sede Cochabamba. Universidad Católica Boliviana "San Pablo" Cochabamba.

Hamodi, C., López Pastor, V. M., & López Pastor, A. T. (2015). Medios, técnicas e instrumentos de evaluación formativa y compartida del aprendizaje en educación superior. Perfiles Educativos, 146 - 161.

Hernandez Falcón, D., Vargas Jiménez, A., & Alumiñas Rivero, J. L. (2020). La importancia de la evaluación de la eficiencia académica en las universidades. Rev. Cubana Edu. Superior vol.39, 39(1).

Hernandez Sampieri, R., Méndez Valencia, S., Mendoza Torrez, C. P., & Cuevas Romo, A. (n.d.). Fundamentos de Investigación. Mc Graw Hill.

Ley Leyva, N. V., & Espinoza Freire, E. E. (2021). Características de la evaluación educativa en el proceso de aprendizaje. Revista Universidad y Sociedad, 363 -370.

Opinión. (2017, Julio 03). UMSS sigue los pasos de UAGRM y dará doble título con diplomado. Retrieved from https://www.opinion.com.bo/articulo/sin-categoria/umss-sigue-pasos-uagrm-dar-aacute-doble-t-iacute-tulo-diplomado/20170703202500583134.html

Reyes García, C. I., & Díaz Megolla, A. (2020). ¿Quiénes Deben Ser Los Agentes Evaluadores Del TFG? Educación XX1, 125-145.