Exploring Virtual Reflective Learning Experiences in Higher Education

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Abstract

As a result of the COVID-19 pandemic, formal education underwent a period of rapid transformation. Beyond this period, the virtual learning environment proposed a reevaluation of curriculum design and didactic strategies. The Classroom Laboratory NTNU-WUT Joint Course (CL) was introduced as a novel learning experience for students at West University of Timisoara (WUT) and the Norwegian University of Science and Technology (NTNU). This experimental course was proposed as part of the Romania-Norway collaboration and incorporates Virtual Project Based Learning (VPBL) in cross-cultural and cross-disciplinary online learning groups. This study aims to describe the learning experiences of Romanian students enrolled at WUT in the CL course during the 2021–2022 academic year. In a quasi-experimental design, 24 Romanian students participated in a seven-week transversal CL course, collaborating with Norwegian peers to develop a solution for a social problem. ••Students made significant gains in all three dimensions targeted by VPBL: skill development, self-regulation of learning, and group interactions in the online environment. In addition, the learning of students was compared based on the field of science they are pursuing (STEM and non-STEM). The results indicate that students enrolled in STEM disciplines demonstrated greater benefits from this instructional approach, as evident in their progress across the three dimensions of PBL. The qualitative analysis of the students' journals reveals a positive learning experience in terms of knowledge acquisition, skill development, and affective engagement. In conclusion, CL and VBPL are valid strategies for online university-level instruction.

Keywords: Virtual Classrooms, Virtual Project-Based Learning, online learning, cross-cultural learning.

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1. Introduction

The online environment has revolutionized education, offering a wide range of possibilities and unique interactions (Ferri et al., 2020). Online learning has long been recognized for its numerous benefits, leading to the implementation of various online teaching options such as distance learning, remote learning, and Massive Open Online Courses (MOOCs) nearly two decades ago (Bates, 2005). The COVID-19 pandemic played a significant role in bringing online learning to the forefront, as it became the primary mode of education worldwide (Dhawan, 2020). As we move beyond the pandemic, we find ourselves in a world that is significantly more digitized, with educators and students alike demonstrating enhanced competency (Myyry et al., 2022) and willingness to utilize internet-based resources (Clary et al., 2022), advanced digital tools, and an accessible global learning landscape (Robson et al., 2022). While online teaching and learning have been extensively studied (Ulum, 2021), there remains a need for rigorous scientific validation to further substantiate their effectiveness. This article contributes to this growing body of research, aiming to provide additional scientific evidence that underscores the validity of the Classroom Laboratory (CL) course concept and the Virtual Project-Based Learning (VPBL) online teaching method.

Higher education institutions (HEIs) have been compelled to reevaluate their entire teaching process, adapting to the challenges of online learning with varying degrees of success (Zhang et al., 2022). As we navigate the post-pandemic stage, it is imperative to identify and sustain best practice models that align with the fundamental mission of HEIs: to educate future professionals to be competent in their field of study but also possess transversal skills, enabling them to effectively utilize new digital technologies and critically reflect on their professional performance (García-Álvarez et al., 2022). The CL course aligns with these objectives as it offers students an active, online learning experience that can be designed both cross-cultural and cross-disciplinary (Dincă et al., 2021). The course's primary aim is to foster the development of transversal skills by engaging students in the exploration of social problems and establishing a continual connection with the labor market (Dincă et al., 2023a). By embracing CL, HEIs can provide students with a dynamic educational framework that prepares them for the demands of a rapidly evolving professional landscape (Berge, 2020).

The CL is an instructional approach that integrates teaching, learning, and research, with all methodological decisions based on rigorous scientific evidence. The CL, as a pedagogical framework, inherently serves as a space for experimentation, simulation of real-world situations, and the application of scientific methods that have contributed to the advancement of knowledge (Craşovan et al., 2022). In the realm of social sciences, CL relies on Project-Based Learning (PBL) as a teaching and learning approach. In the context of this study, CL is realized through online Virtual PBL (VPBL).

The primary objective of CL is to cultivate transversal skills among students, equipping them with the necessary competencies to thrive in a competitive labor market and ensuring their resilience in both career and personal development (Dincă et al.,

2023b). By engaging in CL, students are provided with opportunities to develop critical skills that extend beyond the boundaries of their specific disciplines. These transversal skills encompass areas such as effective communication, teamwork, critical thinking, problem-solving, and reflectivity. In our study, the CL was implemented in a cross-cultural context, with the aim of cultivating transversal skills that encompass cultural understanding, English literacy, and digital skills.

PBL is a highly effective educational approach grounded in constructivist theories, emphasizing active student engagement in real-world problem-solving (Susilowibowo & Tantri Hardini, 2019). By working collaboratively in groups, students apply their knowledge and skills to address authentic problems, cultivating higher-order thinking skills such as critical thinking and decision-making (Wang, 2022). With the integration of virtual technologies, VPBL has emerged, leveraging digital tools to create virtual environments (Mantra et al., 2022), possible to apply for cross-cultural and cross-disciplinary collaboration.

VPBL offers an ideal platform for developing transversal skills (Arwatchananukul et al., 2022). Transversal skills, including communication, teamwork, critical thinking, and cultural understanding, are crucial in today's interconnected world. By engaging in VPBL within CL, students gain global perspectives, enhance their cultural understanding, and refine their communication skills. These skills are transferable and essential for personal and professional success.

The purpose of this study is to describe the learning experiences of Romanian students enrolled in a cross-cultural, cross-disciplinary course, CL, applying the VPBL method. To measure the learning outcomes in relation to transferable skills, as proposed by Dincă et al. (2022), the assessment encompassed three dimensions, in total a set of 14 skills. The first dimension assessed in this study is online self-regulation, which pertains to the capacity of learners to effectively manage and regulate their learning within the online environment (Broadbent et al., 2022). Online self-regulation involves several key components that enable learners to optimize their learning experiences. These components include the ability to establish meaningful and attainable learning goals, exert control over the online environment to ensure access to necessary learning resources, employ strategies that are most effective for individual learning styles, seek assistance and support when required, engage in self-evaluation and reflection, and make adjustments based on these assessments. The second dimension examined in this study is competence development, specifically focusing on competencies within the cognitive domain. This dimension encompasses various key competencies that are crucial for learners to develop in order to enhance their cognitive abilities and problem-solving skills within an online learning environment. The competencies measured within the cognitive domain include creativity, complex problem-solving, meta-cognitive awareness, collaboration, and communication. These competencies collectively contribute to learners' overall cognitive development and their ability to effectively engage in online learning activities. The third dimension examined in this study is group

interaction, which pertains to the interaction skills demonstrated by learners within a group setting in the online learning environment. This dimension focuses on the various aspects of group dynamics and the skills necessary for effective collaboration and interaction among group members. Group interaction involves several key skills that contribute to productive group work and successful achievement of shared goals. These skills include exploratory questions, cumulative reasoning, and handling conflicts.

2. Methodology

The purpose of this study is to describe the learning experiences of Romanian students enrolled in a cross-cultural, cross-disciplinary course, CL applying the VPBL method. By assessing the learning outcomes and investigating the perceptions, reflections, and narratives of the participants, this research aims to provide a detailed and nuanced understanding of how this innovative pedagogical approach impacts the learning outcomes of Romanian students. Additionally, this study seeks to examine the potential of the VPBL method, specifically in the context of the CL approach, for fostering cross-cultural understanding and facilitating knowledge integration across multiple disciplines. Through mixed research methods such as standardized questionnaires and reflective journals, this study aims to generate valuable insights that contribute to the existing body of knowledge on VPBL and its applicability in diverse educational settings. Ultimately, the outcomes of this study are expected to offer practical implications for higher education curricular designers and policymakers who are interested in incorporating effective pedagogical strategies to enhance student learning experiences in cross-cultural and cross-disciplinary courses.

Research question: How does Romanian students experience the Classroom Laboratory course?

Research objectives:

The primary objectives of this study are as follows:

1. To evaluate the effects of the VPBL teaching method, as implemented within the CL, a cross-cultural and cross-disciplinary course, on students' self-assessed learning outcomes.
2. To provide a comprehensive description of the CL experience from the reflections of the students, focusing on three key dimensions: knowledge, emotions, and competencies.

Research design

This research employed a quasi-experimental study design, incorporating mixed methods to assess the impact of the VPBL teaching method within a cross-cultural and cross-disciplinary educational setting. The learning outcomes were comprehensively

evaluated through a mixed methodology approach, combining quantitative questionnaires and qualitative reflective journals. This methodological choice allowed for an in-depth analysis of the learning outcomes by integrating standardized measurements with the perspectives of the students themselves.

Participants

Data were collected from a convenience sample comprising 24 students who were enrolled in the CL, a transversal course offered at the West University of Timisoara, Romania (WUT) and the Norwegian University of Science and Technology (NTNU). At the WUT, students are required to select a transversal course for three semesters that diverges from their primary specialization. In this context, the CL was proposed as one such transversal course, designed to develop the transversal skills demanded by the labor market. While a total of 27 Romanian students participated in this transversal course, the research included only 24 students who completed all the requisite processes, including the evaluation tools and active participation in course activities. The majority of the participants in this study consisted of women, accounting for 70.83% of the sample. In terms of academic year, 54.16% of the participants were enrolled in their second year, the rest in the third year of study. The participants represented a diverse range of specializations, including Human Resources, Preparatory and Primary School Pedagogy, Medical Chemistry, Kinetotherapy and Special Motricity, Informatics (in English Language), Digital Media, Territorial Planning, Economy Informatics, Applied Modern Languages, Geography, Informatics, Sociology, Fine Arts, Biochemistry, Physical Education and Sports, and Music. For analytical purposes, the participants were classified into two categories based on their specialization: STEM subjects, consisting of 13 participants (54.16%), and non-STEM subjects, consisting of 11 participants (45.84%).

Instruments

For a more comprehensive description of the student experience, quantitative and qualitative methods were used to compile the data. The quantitative instrument was composed by incorporating two dimensions (online self-regulation and competence development) with 11 scales from the Project-based Learning Survey (Wu et al., 2021) and one dimension (group interaction) with three scales from the Group Interaction Questionnaire (Visschers-Pleijers et al., 2005). The assessment instrument comprised a total of 55 items, each rated on a 5-point Likert scale. A higher score on the scale indicated a greater level of proficiency or ability in the measured areas. The objective of using this instrument was to assess students' learning outcomes across three dimensions: learning skills developed through the VPBL method, transversal skills, and collaborative skills within a group setting. By conducting measurements of these dimensions at both the beginning and conclusion of the course, it will enable the assessment of students' progress and ascertain the effectiveness of the implemented teaching method. The

qualitative component of the research involved the utilization of an online learning journal, which served as a platform for students to engage in reflective practices encompassing three key dimensions: knowledge, competencies, and emotions. Within this framework, the students were prompted to respond to various reflection themes through online tasks. However, this study focuses on the analysis of student reflections pertaining to two specific themes: (1) the articulation of their thoughts, emotions, and expectations in relation to the CL joint course, and (2) the description of what they learned and how they acquired knowledge within the CL learning experience.

Procedure

The collaboration between WUT and NTNU resulted in the joint design and implementation of the CL course. For the academic year under analysis in this article, 2021-2022, the course underwent collaborative development by both universities six months prior to its commencement. In the frame of the EEA 21-COP-0004 VR-classrooms project, building upon the insights derived from the previous edition, adjustments were made, leading to the formulation of the course structure described in the following section. The course spanned a duration of seven weeks, encompassing two modules per week, with three hours allocated for each module. During this period, Romanian and Norwegian students interacted and collaborated exclusively online, in virtual classrooms. The administration of the quantitative instrument took place in the pretest and posttest phase, both at the onset of the course and in its final week. Additionally, the reflection journal was administered at the conclusion of each of the seven weeks. However, for the purposes of this article, the analysis focused on three specific time points, following the TTT model proposed by Dincă et al. (2023): the end of the first meeting, the fourth week (mid-course), and the seventh week.

Classroom laboratory: an innovative course

The Classroom Lab course brought together teachers, students, researchers, and experts from two universities, UVT from Romania and NTNU from Norway, as well as various organizations from Romania. The main objective of the course is to develop a set of transversal competencies in students from different specializations and study programs, within an authentic learning context that aims to closely resemble real-life situations and the work life of the future graduates students.

The NTNU and WUT teachers and researchers collaborated in designing the CL course and continuously sought to improve it over the course of its implementation. In addition to its instructional purpose of teaching and developing competencies, the course also incorporated a research component, as we believe that teaching should be evidence-based.

The competencies we aimed to develop are the transversal competencies of the future, such as interdisciplinary teamwork, decision-making, critical thinking, reflective

practice and effective communication. The curriculum design of the course revolved around VPBL method, addressing real-life problems that individuals may encounter in a global labor market. Among the social issues tackled were the integration of people with disabilities, the integration of Roma ethnic minority individuals, the integration and reintegration of former offenders, as well as current issues like the climate-change and energy crisis. These social issues were suggested by specialists or representatives from various organizations in Romania with whom we collaborated. Throughout the instructional activities, these individuals willingly acted as resource persons whom students could consult for resolving real-life situations.

The course was conducted collaboratively, entirely in an online format, over a duration of 28 hours. The students were organized into mixed teams, consisting of students from various specializations across the two universities. The range of specializations was extensive, encompassing STEM and non-STEM fields. The course also included several meetings in which the teams of Romanian and international professors provided input on topics related to distance communication or social issues. On a weekly basis, during a three-hour time slot, students and professors from the two universities would meet for counseling sessions, guidance, and the presentation of project progress and interactions. Time was allocated for student-to-student meetings as well as for addressing any uncertainties or challenges they may have encountered.

Throughout the course, students worked together, reaching a mutual agreement on a research topic and making efforts to understand the chosen subject matter, as well as identifying possible solutions to the selected issue. The students had the freedom to choose their own platforms or means of digital communication, decided on the mode of collaboration, and negotiated their interaction, task distribution and learning time together.

Student assessment was conducted through the presentation of projects, but an essential component of the evaluation process was also the students' reflections and assessment of their own engagement and learning process. Specialists or representatives from various NGOs interested in the addressed issues were invited and participated in the evaluation sessions.

Implementing this course, bringing together students from different educational systems, different specializations, and diverse cultural backgrounds, posed a significant challenge for both the students and us, as educators. One aspect that has been improved from one year to another was the allocation of two sessions before the commencement of shared activities among students, aimed at explaining the course's execution to the Romanian students and developing a set of skills necessary for teamwork interactions in different cultural contexts, which were insufficiently or even not developed within the Romanian educational system.

CL is an innovative course because it is co-constructed throughout its implementation. It is not a course consisting of a set of lectures or tasks that are related to artificial or simulated real-life contexts. Co-construction is achieved by students

themselves, through their involvement in choosing a topic, a social problem from the public agenda, for which they must study it in an interdisciplinary team and with the contribution of local experts, and find realistic solutions to the identified problem. We believe that the strong reflective component on their own learning process and the analysis of their learning journey alongside others are elements that should be integrated into the university curriculum.

3. Results

Quantitative data analysis

Learning outcomes

The instrument utilized in this study assessed a total of 14 skills, categorized into three dimensions, administered at two different time points: pretest and posttest. The 14 skills encompassed the following:

1. Online self-regulation (OS) dimension:
    - Goal setting (GS)
    - Environment structuring (ES)
    - Task strategies (TS)
    - Time management (TM)
    - Help seeking (HS)
    - Self-evaluation (SE)
2. Competence development dimension (CD):
    - Creativity (CRE)
    - Complex Problem-Solving (CPS)
    - Meta-Cognitive Awareness (MCA)
    - Collaboration (COL)
    - Communication (COM)
3. Group interactions dimension (GI):
    - Exploratory questions (EQ)
    - Cumulative reasoning (CR)
    - Handling conflicts (HC)

To address the first objective of this study, which was to evaluate the effects of the VPBL teaching method implemented within CL on students' learning outcomes, descriptive statistics and pretest-posttest comparisons were conducted. The data analysis involved the utilization of the IBM SPSS Statistics (Version 20) statistical software to perform the necessary statistical calculations. By employing these analytical techniques, the researchers aimed to examine the changes in students' learning outcomes before and after their engagement with the VPBL teaching method in the CL course.

To determine the strengths and weaknesses in students' self-evaluated abilities, descriptive statistics were employed to analyze the measured variables. This analysis was conducted at two levels: the entire participant group and separate subgroups

consisting of students enrolled in STEM and non-STEM specializations (Table 1). By conducting separate analyses for these two groups, the researchers aimed to identify any differences in the representation of abilities and dimensions between STEM and non-STEM students. This approach allowed for a comprehensive assessment of the self-evaluation results, enabling the identification of both common and distinct patterns in the perceptions of abilities and dimensions within each group.

Table 1:

The hierarchy of skills presented increasingly (by mean value) at pretest and posttest.

Whole group (N=24)				STEM (N=13)				Non-STEM (N=11)			
T1	**M**	**T2**	**M**	**T1**		**T2**	**M**	**T1**	**M**	**T2**	**M**
TS	2.94	HC	3.00	HC	3.12	HC	3.10	TS	2.61	HC	2.87
HC	2.97	TS	3.36	TS	3.23	TS	3.57	HC	2.78	TS	3.11
TM	3.15	TM	3.38	TM	3.33	TM	3.61	SE	2.88	TM	3.12
SE	3.25	SE	3.60	SE	3.55	SE	3.98	TM	2.93	SE	3.15
CRE	3.45	CRE	3.78	CRE	3.61	CRE	3.98	HS	3.15	CRE	3.54
HS	3.62	MCA	3.91	MCA	3.92	MCA	4.15	CRE	3.27	HS	3.56
EQ	3.69	HS	3.93	EQ	4.00	HS	4.25	EQ	3.34	MCA	3.63
MCA	3.70	ES	4.08	HS	4.01	ES	4.26	CR	3.34	CR	3.81
CR	3.76	EQ	4.15	CR	4.11	GS	4.30	MCA	3.43	CPS	3.84
GS	3.93	CR	4.18	GS	4.16	EQ	4.40	COM	3.50	ES	3.86
COM	3.94	GS	4.21	COL	4.30	COM	4.50	CPS	3.52	EQ	3.86
CPS	3.97	COM	4.22	COM	4.32	CR	4.50	ES	3.54	COM	3.90
ES	3.98	CPS	4.23	ES	4.36	COL	4.56	GS	3.65	GS	4.10
COL	4.02	COL	4.44	CPS	4.36	CPS	4.57	COL	3.69	COL	4.30
GI	3.47	OS	3.76	GI	3.74	OS	4.00	OS	3.13	OS	3.48
OS	3.48	GI	3.78	OS	3.77	GI	4.00	GI	3.15	GI	3.52
CD	3.82	CD	4.12	CD	4.10	CD	4.35	CD	3.48	CD	3.84

At the whole group level, the initial self-perceived skill that received the highest rating was collaboration (M=4.02), indicating that students believed they possessed strong collaborative abilities. Conversely, the skill perceived as least developed at the beginning of the course was task strategies (M=2.94), suggesting that students felt they had room for improvement in this area.

When examining the STEM subgroup, both at the beginning and end of the course, complex problem-solving (M=4.36) was identified as the skill with the highest self-perceived competency. On the other hand, handling conflicts (M=3.12) was perceived as the least developed skill within this subgroup.

In the non-STEM subgroup, collaboration (M=3.69) was regarded as the most proficient ability, while task strategies (M=2.61) were seen as the least developed skill.

Upon completion of the course, the hierarchy of self-perceived abilities did not undergo significant changes for both the whole group and the STEM and non-STEM subgroups. The relative strengths and weaknesses remained consistent, indicating a degree of stability in the students' self-perceptions over the duration of the course.

Measuring progress

To ascertain the presence of positive learning outcomes following students' participation in the CL, specifically in terms of skill development, a paired sample t-test was conducted at the whole group level.

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between the posttest and pretest values of the three measured dimensions (Table 2). All the abilities from the three dimensions increased significantly post intervention: group interaction (t=2.62, p=.015, d=0.53); competence development (t=2.69, p=.013, d=0.55); online self-regulation (t=2.64, p=.015, d=0.53).

Table 2:

Results of paired sample t test posttest-pretest 3 VPBL dimensions

Dimension	Posttest		Pretest		t(23)	p	Cohen`s d	Strength
	M	*SD*	*M*	*SD*				
Group interaction	3.78	.54	3.47	.59	2.62	.015	.53	Medium
Competence development	4,12	.53	3.82	.69	2.69	.013	.55	Medium
Online self-regulation	3.76	.62	3.48	.71	2.64	.015	.53	Medium

Also, a paired sample t test was conducted to determine the students` progression on the 14 specific skills. In Table 3 only the significant differences are presented.

Table 3:

Results of significant differences of the paired sample t test posttest-pretest 14 VPBL skills

Abilities	Posttest		Pretest		t(23)	p	Cohen`s d	Strength
	M	*SD*	*M*	*SD*				
Goal setting	4.21	.50	3.93	.74	2.13	.044	.43	Small
Task strategies	3.36	.90	2.94	.98	2.87	.009	.58	Medium
Self-eval	3.60	.84	3.25	.70	2.87	.009	.58	Medium
Creativity	3.78	.55	3.45	.72	2.36	.027	.48	Small
Collaboration	4.44	.64	4.02	.86	2.41	.024	.49	Small
Exploratory in	4.15	.54	3.69	.74	3.47	.002	.71	Medium
Cumulative re	4.18	.61	3.76	.73	2.84	.009	.58	Medium

The abilities that increased significantly post intervention were: goal setting (t=2.13, p=.044, d=0.43); task strategies (t=2.87, p=.009, d=0.58); self-evaluation (t=2.87, p=.009, d=0.58); creativity (t=2.36, p=.027, d=0.48); collaboration (t=2.41, p=.024, d=0.49); exploratory inquiry (t=3.47, p=.002, d=0.58); cumulative reasoning (t=2.84, p=.009, d=0.58). Out of the 14 skills measured, seven skills demonstrated improvement following

the intervention. The magnitude of the effect sizes varied, with some exhibiting small effects while others showed medium effects. Among the measured skills, exploratory inquiry exhibited the greatest effect size, indicating a notable improvement. Following exploratory inquiry, the skills that displayed relatively stronger effects were task strategies, self-evaluation, and cumulative reasoning. These findings suggest that the intervention, namely the Classroom Laboratory, had a positive impact on these skills, albeit with varying degrees of effectiveness.

Differences between STEM and non-STEM students

An independent samples t-test was used to determine whether there was a statistically significant mean difference between the STEM and non-STEM values of the three measured dimensions (Table 4). All the abilities from the three dimensions were significantly higher for the STEM students from the beginning: group interaction (t=2.66, p=.016, d=2.66); competence development (t=2.24, p=.043, d=2.24); online self-regulation (t=2.36, p=.030, d=2.36). Also, in table 4 the significant mean differences for the VPBL abilities are presented. The students that studies STEM specialties have significant better abilities than non-STEM students for: help seeking (t=4.56, p=.044, d=2.30); self-evaluation (t=2.54, p=.019, d=2.54); complex problem solving (t=2.78, p=.016, d=2.78); meta cognitive abilities (t=5.60, p=.027, d=1.45); communication (t=2.56, p=.024, d=2.56); exploratory inquiry (t=2.26, p=.04, d=2.26); cumulative reasoning (t=2.61, p=.013, d=0.81).

Table 4:

Results of significant differences for the independent sample t test posttest-pretest 14 VPBL skills and dimensions

Dimension/ ability	STEM		Non-STEM		t	p	Cohen`s d	Strength
	M	*SD*	*M*	*SD*				
Help seeking	4.91	.61	4.35	.90	4.56	.044	2.30	Large
Self-eval	3.55	.57	2.88	.69	2.54	.019	2.54	Large
Complex Prob	4.36	.34	3.52	.95	2.78	.016	2.78	Large
Meta cognitiv	3.92	.62	3.43	1.00	5.60	.027	1.45	Large
Communication	4.32	.41	3.50	1.00	2.56	.024	2.56	Large
Exploratory in	4.00	.44	3.34	.87	2.26	.040	2.26	Large
Cumulative re	4.11	.42	3.34	.82	2.61	.013	2.81	Large
Group interact	3.74	.45	3.15	.60	2.66	.016	2.66	Large
Competence	4.10	.36	3.48	.85	2.24	.043	2.24	Large
Online selfreg	3.77	.50	3.13	.77	2.36	.030	2.36	Large

Out of the 14 skills measured, STEM students rated seven skills as more developed compared to non-STEM students (Table 4). The effect sizes observed were of large magnitude, indicating a substantial difference between the two groups. Among these skills, cumulative reasoning exhibited the greatest effect size, followed by complex problem solving. These findings emphasize the distinct strengths of STEM students in these particular skills.

To examine whether there were differential progress outcomes between students enrolled in STEM specializations and non-STEM students following the intervention, a t-test for dependent samples was conducted. This statistical analysis compared the pretest and posttest scores within each group separately, allowing for a comparison of progress made by students in STEM specializations versus non-STEM specializations.

Table 5:

Results of significant differences for the paired sample t test pretest 14 VPBL skills STEM students

Dimension/ ability	Posttest		Pretest		t	p	Cohen`s d	Strength
	M	*SD*	*M*	*SD*				
Task strategies	3.57	1.02	3.23	1.02	2.54	.026	0.63	Medium
Self-eval	3.98	.73	3.55	.57	3.54	.019	0.72	Medium
Exploratory in	4.40	.50	4.00	.54	3.00	.011	0.83	Large
Cumulative re	4.50	.55	4.11	.42	2.30	.040	0.64	Medium
Group interact	4.00	.43	3.74	.45	2.29	.040	0.63	Medium
Competence	4.35	.44	4.10	.36	2.34	.037	0.64	Medium
Online selfreg	4.00	.62	3.77	.50	2.21	.047	0.61	Medium

For students studying STEM specializations, a significant progress was registered, with an average effect, for all three dimensions (Table 5): group interaction (t=2.29, p=.040, d=0.63); competence development (t=2.34, p=.037, d=0.64); online self-regulation (t=2.21, p=.047, d=0.61). Also, significant progress was observed on four abilities: task strategies (t=2.54, p=.026, d=0.63); self-evaluation (t=3.54, p=.019, d=0.63); exploratory inquiry (t=3.00, p=.011, d=0.72); cumulative reasoning (t=2.30, p=.040, d=0.64). The greatest progress with the greatest magnitude of effect was observed for exploratory inquiry.

Among students studying non-STEM disciplines, the analysis revealed no significant progress in any of the three dimensions or the 14 measured abilities. This implies that the intervention implemented in the Classroom Laboratory did not lead to notable improvements in the skills assessed within this particular subgroup. These findings highlight the need for further investigation and potential modifications in the instructional approach to effectively address the learning needs of students enrolled in non-STEM disciplines.

Qualitative findings

To gain a deeper understanding of the impact of the VPBL method and the CL course on the students, qualitative methods were also employed in this study. The students were instructed to keep a learning journal throughout the 7-week duration of the course, during which they worked on projects centered on social themes. In this study, we specifically analyze the responses related to two themes from the journal entries. The

first theme focused on the students' reflections regarding their thoughts, emotions, and expectations in relation to the CL joint course. The second theme aimed to capture the students' descriptions of what they learned and how they acquired knowledge within the CL joint course experience. The students' responses were considered at three different phases of the course, following the TTT model proposed by Dincă et al. (2023), namely in week one, week four, and week seven.

To address the research question of how Romanian students experienced the CL course, an inductive thematic content analysis was conducted on the students' journal entries. This analysis aimed to identify and explore emerging themes and patterns within the data. The findings derived from this content analysis are presented in the subsequent sections, providing valuable insights into the students' experiences throughout the course.

During the analysis, four main themes emerged, capturing various aspects of the students' experiences in the CL course. These themes include the perception of CL as a good practice for the development of transversal skills, CL as an opportunity for personal development, the cultural differences observed among Norwegian students, and qualitative assessments of the CL course. These themes will be further examined and analyzed in relation to the three phases of the TTT model: teambuilding, teamwork, and team performance. During the initial phase of teambuilding, students engaged in the establishment of relationships with their partners, undergoing a process of knowledge acquisition and self-discovery. Furthermore, this phase fostered the development of trust and facilitated the identification of effective communication strategies within the cross-cultural online environment. During the middle phase of the course, which is characterized by teamwork, the students actively engaged in the process of project realization, with a particular emphasis on the work process. This stage provided an opportunity for the students to further develop their communication, collaboration, and problem-solving skills. The final phase of the course, known as team performance, marks the culmination of the students' efforts as they complete their projects and reflect upon their overall learning experience. During this phase, the students assess their performance as a team and draw conclusions regarding the knowledge and skills acquired throughout the course. It is a critical stage where they evaluate their collective achievements, identify areas of improvement, and reflect on the impact of their collaborative efforts.

CL as a good practice for the development of transversal skills

In their learning journals, numerous students made references to various transversal skills, including communication, teamwork, and cultural understanding. Each of these skills will be analyzed individually and examined in relation to their evolution throughout the course. By closely examining the students' reflections, we aim to assess the impact of the CL approach on the development of these transversal skills.

Communication

Communication is recognized as a crucial skill not only within the context of learning but also in learning groups and professional environments. This importance is further magnified in the cross-cultural setting of the CL course, where communication occurred primarily online and in English. The emphasis on communication during the teambuilding phase highlights its significance in establishing a solid foundation for collaborative work and ensuring effective interaction among participants.

During the initial stages of the course, students expressed challenges encountered in the communication process, particularly due to the utilization of English as the primary language and the involvement of non-native speakers, including foreign partners. Many students described feelings of anxiety, embarrassment, and a lack of confidence in their English communication abilities. They acknowledged that language proficiency served as a potential barrier to effective communication, emphasizing the need for the development of communication skills to ensure project success. Additionally, students initially encountered difficulties in understanding the varied accents present among Norwegian students when communicating in English. However, with time, they quickly adapted and became accustomed to the different accents, thereby enhancing their ability to comprehend and engage in effective cross-cultural communication. Throughout the subsequent weeks of the course, students consistently emphasized the significance of effective communication in various aspects, such as decision-making, argumentation, and problem-solving. As the course progressed, the language barriers that initially posed challenges were successfully overcome. Romanian students demonstrated an increased level of confidence in their communication skills, which facilitated their active participation in discussions and enabled them to effectively express their ideas and opinions. At the conclusion of the course, the students expressed highly positive sentiments regarding the progress made in their communication skills. They viewed the CL course as a valuable opportunity to enhance their proficiency in English communication and to bolster their confidence in this particular aspect. The students acknowledged the significance of engaging in cross-cultural collaboration and recognized the course's contribution to their growth and development.

"*I was very emotional and shy at the beginning, but I don't regret that I participated in this course; on the contrary, I communicated more in the last 2 months than in the last 2 years (within WUT, with other students)*" (STEM student 21).

Teamwork

The VPBL teaching method is fundamentally centered around teamwork, thereby naturally facilitating the development of teamwork skills. In the initial stages of the course, students frequently referenced the challenges associated with teamwork, yet simultaneously discovered its inherent value and benefits. During the teamwork phase, the students acquired a comprehensive understanding of the essential principles

underpinning effective collaboration and recognized the necessity of adhering to these principles to ensure optimal outcomes. Moreover, they experienced firsthand the significance of trust and mutual reliance within a team, realizing that through collaboration, they could learn and accomplish more collectively. As the projects neared completion in the final phase, the students expressed their pride in the final product and conveyed gratitude for the valuable lessons learned through collaboration with diverse individuals. Their reflections underscored the transformative impact of the CL course in cultivating teamwork skills, fostering a sense of unity, and cultivating a deep appreciation for the power of collective effort.

"*In these past weeks, I have learned a lot of new things and ways of looking at a problem, all of which can be attributed in large part to the fact that our groups were so diverse that I couldn't help but have a great time learning*" (STEM student 19).

Cultural understanding

Cultural understanding emerged as a skill that was directly nurtured through the process of cross-cultural collaboration. Over the duration of the course, the students keenly observed and acknowledged the disparities between themselves and their Norwegian colleagues. Initially, a sense of timidity and reservation prevailed, with some students inadvertently undervaluing their own contributions in the presence of their international peers. However, as they engaged in interactive discussions and collaborated on various projects, a remarkable transformation occurred. Gradually, the students began to relax and shed their inhibitions, recognizing that they were not inherently inferior but rather uniquely positioned to appreciate and embrace the diversity inherent in their collaborative efforts. Through these experiences, they came to realize that cultural differences served as invaluable opportunities for learning and personal growth. In fact, several students even adopted the behaviors and learning approaches exhibited by their Norwegian counterparts as role models, further attesting to the profound impact of cross-cultural collaboration in fostering cultural understanding and nurturing a spirit of inclusivity. *"I saw differences between Romanian and Norwegian cultures, differences that I thought about a lot after I left the meeting. I learned a lot about them, about me, and about diversity. Very interesting experience*!" (non-STEM student 17).

CL as a good opportunity for personal development

The students' reflections extended beyond the domain of professional and transversal skills, encompassing personal introspection and self-analysis. Particularly during the initial phase of mutual acquaintance and self-reflection, as well as during the concluding phase of drawing insights, these introspective considerations were prominent. In the initial phase, a notable trend was observed wherein students displayed a tendency to underestimate their own worth in the presence of their Norwegian colleagues. They candidly expressed feelings of shyness, fear, and withdrawal resulting from a lack of self-

confidence. However, as they actively collaborated on projects, a transformative shift occurred. Gradually, the students gained confidence in their abilities, became more open and engaged, and even experienced a sense of enjoyment and fulfillment. Upon conducting the final analysis, several students declared that their participation in the course had significantly increased their self-confidence and facilitated personal development. It became evident that the CL course not only served as a catalyst for professional growth but also as a platform for enhancing self-confidence and fostering personal transformation. "*I also learned to open up more to new people, to be empathetic and understanding, and to be altruistic by the fact that during the 7 weeks in which I participated in the courses of this discipline, I had to be like this and behave accordingly*" (STEM student 11).

Cultural differences observed among Norwegian students.

From the beginning, the Romanian students expressed great interest in the cross-cultural aspect of the course. They keenly observed the Norwegian students and frequently engaged in reflective observations. Initially, these observations were characterized by a sense of inferiority, as the Romanian students held the Norwegian students in high regard, perceiving them to possess excellent English language skills and an easygoing nature. However, over time, a transformation occurred in their perspective, as the Romanian students began to observe the Norwegians from a position of equality. They noted the Norwegians' patience, attentiveness, active involvement, and conscientiousness. By the course's conclusion, the Romanian students came to the realization that they had much to learn from their Norwegian colleagues, particularly in terms of ease, relaxation, and the joy of interpersonal interactions. The majority of students expressed that collaborating with their Norwegian peers was a genuine pleasure from which they gained valuable insights and experiences. "*Seeing them, I noticed that my confidence increased that I could also someday create this type of atmosphere and this feeling of "naturalness" in learning*" (STEM student 7).

Qualitative assessments of the CL course

In their reflective journals, numerous students expressed their appreciation for the CL, particularly during the conclusion phase, as a distinct and rewarding learning experience. Several positive aspects stood out for the students. Foremost was the cross-cultural nature of the course, which enriched their perspectives and broadened their horizons. The project-based learning approach also garnered praise, as it provided them with opportunities for collaborative and experiential learning. Students valued the utilization of their critical thinking and problem-solving skills throughout the course. They also highlighted the practicality of CL, noting its non-directive nature and the absence of constant teacher intervention.

Furthermore, students acknowledged CL as a platform that facilitated their acquisition of new digital tools, such as PowerPoint Online, Canva, and virtual reality applications. The terms used to describe CL encompassed a range of positive sentiments: pleasant, beautiful, challenging, interactive, fun, and interesting. Students conveyed a sense of satisfaction, excellence, and excitement regarding their participation in the course. Many expressed a desire to repeat the experience if given the opportunity. "*In general, the discussions with my colleagues from other specializations, faculties, and even countries made me happy because I had the opportunity to learn so many new things. My expectations were high, I must admit, but they were more than exceeded*" (STEM student 15).

4. Discussion

The present study is conducted as part of the research activities undertaken within the project EEA 21-COP-0004 "Bringing Real Life into Virtual Classrooms" (VR-classrooms), implemented by the West University of Timisoara, Romania, in collaboration with the Norwegian University of Science and Technology, Norway. This project is supported by the EEA Financial Mechanism 2014-2021. Within the project, the CL model has been developed as a unique curricular approach that combines learning and research activities.

CL serves as both a learning and a research space, with the aim of integrating theory and practice. The central teaching method employed in CL is VPBL, which is implemented in a cross-cultural context. The students engage in collaborative projects, working in mixed groups consisting of both Romanian and Norwegian students. The primary objective is to address and solve social problems through the development of projects. Other studies researched PBL in cross-disciplinary (MacLeod & van der Veen, 2019; St John et al., 2023) or cross-cultural context (Shadiev et al., 2015), some with technology (ChanLin, 2008) and online delivery (Çakiroğlu & Erdemir, 2018). Unlike other research that studied these variables separately, our research observes the cumulative effect, with an emphasis on cross-cultural learning context.

Through the collaborative nature of the projects, students had the opportunity to develop transversal skills that are highly valued in the labor market. These skills go beyond professional knowledge and include competencies such as communication, teamwork, critical thinking, and problem-solving.

The aim of this study is to investigate the impact of the VPBL method within the CL course on students' learning outcomes. Many studies recognize the difficulties of assessment of the learning outcomes and students' progress in PBL settings (Wengrowicz et al., 2016). By employing a mixed-methods approach, combining quantitative and qualitative data analysis, this research seeks to overcome these difficulties and provide a comprehensive understanding of the effects of CL on students' skill acquisition and overall learning experiences.

The measurement of transversal skills within the CL course was conducted using a questionnaire comprising three dimensions and a total of 14 transversal skills. The purpose of this measurement was to assess the progress made by students in the development of these skills throughout the course.

The findings reveal significant progress in students` learning outcomes (similar with Mares et al., 2021). The progress was significant in all three dimensions and specifically in seven of the measured transversal skills. These skills include goal setting (Kokotsaki et al., 2016), task strategies (similar with Kalemkuş & Bulut-Özek, 2022), self-evaluation (Başbay & Ateş, 2009), creativity (Biasutti & EL-Deghaidy, 2014), collaboration (Asan & Haliloglu, 2005), exploratory inquiry, and cumulative reasoning (similar with Romera et al., 2016). The significant improvement observed in these skills indicates the successful application of CL in promoting the development of transversal competencies among students, especially skills related to learning management (similar to Ali et al., 2013), collaborative learning (similar with Li et al., 2015; Pinho-Lopes & Macedo, 2015) and problem solving (similar to Nation, 2008; Young & Legister, 2018).

The impact of the CL approach was also examined in relation to students studying STEM and non-STEM specializations. Many studies investigated the PBL in STEM (Evans et al., 2017; Ludwig et al., 2017; Buber & Unal Coban, 2023) or non-STEM disciplines (Li et al., 2015; Tanaka, 2022). In this study a comparison was made between the effectiveness of teaching with VPBL between students enrolled in STEM versus non-STEM majors. The objective was to assess whether there were differences in the development of transversal skills between these two groups. The results revealed notable disparities between STEM and non-STEM students, suggesting varying effects of CL on their skill development.

From the initial stages of the course, STEM students rated seven skills as more developed compared to their non-STEM colleagues, as studies revealed that STEM and PBL is the best combination (Lee et al., 2019). This discrepancy indicates that STEM students entered the CL course with a higher level of proficiency in these particular skills. The effect sizes observed were of large magnitude, indicating a substantial difference between the two groups. Among these skills, cumulative reasoning exhibited the greatest effect size, emphasizing the strength of STEM students in this particular skill. Additionally, complex problem-solving skills demonstrated a notable effect size, further underscoring the distinct strengths of STEM students in these areas (Tan et al., 2022).

Furthermore, when examining the progress made by students throughout the course, it was evident that STEM students showed significant advancements in all three dimensions and four specific skills. In contrast, non-STEM students did not exhibit significant progress in any of the dimensions or skills measured. This disparity raises important considerations regarding the instructional approach and support provided to non-STEM students within the CL context.

The findings suggest the need for further investigation into the factors that may contribute to the differential impact of CL on students from STEM and non-STEM

disciplines. It is crucial to identify and address potential barriers or limitations that may hinder the progress of non-STEM students in developing transversal skills. Modifications in the instructional approach, adapted interventions, or additional support may be necessary to enhance the learning experience and outcomes for non-STEM students.

These findings have significant implications for teachers and policymakers, as they highlight the importance of considering discipline-specific characteristics and learning needs when designing and implementing innovative instructional approaches, like CL. Addressing the unique challenges faced by non-STEM students can contribute to a more equitable and inclusive educational environment, ensuring that all students have equal opportunities for skill development and success.

In order to gain a more comprehensive understanding of the impact of the VPBL method and the CL course on the students, qualitative reflective journals analyses were incorporated in this study. The reflective journal was also used by other studies on PBL, being considered a valid and efficient evaluation method (Kim, 2017). A thematic content analysis was employed to examine the responses provided by the students in their reflective learning journals. The students' journal entries were analyzed at three different time points, aligned with the stages of the TTT model (Dincă et al., 2023). This analytical framework facilitated an examination of the students' learning progression and the overall impact of the CL course. Within these journal entries, four key thematic categories emerged, providing valuable insights into the students' experiences.

The first theme that emerged from the analysis centered on the perception of CL and VPBL as a method for developing transversal skills (similar with Bell, 2010; Biasutti & EL-Deghaidy, 2014). Students acknowledged the role of CL and VPBL in fostering the development of various skills essential for their future endeavors. Specifically, they recognized the importance of communication (Han et al., 2016), teamwork, cultural understanding (similar to Shadiev et al., 2015), and critical thinking (similar to Kim, 2017) as skills that were enhanced through their participation in the CL course. The second theme focused on CL as an opportunity for personal development. They described how their initial feelings of shyness, lack of confidence, and language barriers gradually transformed into increased self-assurance and self-efficacy (similar to Perrault & Albert, 2017), active engagement (similar to Lou & Kim MacGregor, 2004), and enjoyment of the learning process. The CL course provided a platform for students to challenge themselves, step out of their comfort zones, and develop personally. The third theme that emerged from the analysis pertained to the students' observations and reflections on the cultural differences between themselves and their Norwegian peers. Initially, students expressed feelings of inferiority and self-depreciation in comparison to the Norwegian students. However, as the collaboration progressed, they began to appreciate and value the diversity of perspectives, recognizing the learning opportunities presented by working with individuals from different cultural backgrounds. They also identified positive qualities in their Norwegian peers, such as patience, attentiveness, and conscientiousness, which they sought to emulate. The fourth and final theme revolved

around the students' general assessments of the CL course. Students expressed positive sentiments regarding their overall experience. They found the cross-cultural aspect of the course particularly intriguing and appreciated the project-based learning approach, group dynamics, and the opportunity to apply their critical thinking and problem-solving skills. Furthermore, they highlighted the practical nature of the course, the absence of constant teacher intervention, and the exposure to new digital tools as valuable aspects of their CL experience.

The present study has several potential limitations. Firstly, the study was conducted within the context of a specific project and involved a limited sample size of students from the partnering universities. The findings may not be generalizable to other educational settings or student populations. Further research with larger and more diverse samples is needed to enhance the external validity of the results.

Secondly, the study focused on the impact of the VPBL method and the CL course on the development of transversal skills and personal growth. Other factors that may influence student learning outcomes, such as prior knowledge, motivation, and individual learning styles, were not extensively examined in this study. Future research could consider incorporating a more comprehensive set of variables to gain a more nuanced understanding of the factors influencing student outcomes in CL environments.

Lastly, the study focused on the perspectives of Romanian students participating in a cross-cultural collaboration with Norwegian students. The potential differences in cultural backgrounds, educational systems, and learning contexts between the two groups may have influenced the results. It would be valuable to explore the experiences of students from other cultural backgrounds and educational contexts to further investigate the generalizability of the findings.

Despite these limitations, the current study offers valuable insights into the impact of the VPBL method and the CL course on students' transversal skill development, personal growth, and cross-cultural collaboration. The findings provide a foundation for further research and potential improvements in instructional approaches aimed at enhancing student learning outcomes in CL environments.

5. Conclusion

In conclusion, the present study investigated the impact of the VPBL method within the CL course on students' learning outcomes, with a particular focus on the development of transversal skills. The findings demonstrated significant progress in students' learning outcomes across all three dimensions and specifically in seven measured transversal skills. These skills encompassed goal setting, task strategies, self-evaluation, creativity, collaboration, exploratory inquiry, and cumulative reasoning. The results underscored the successful application of CL in promoting the development of transversal competencies among students, particularly in areas related to learning management, collaborative learning, and problem solving.

Moreover, the study explored the differential impact of the CL method on students studying STEM and non-STEM specializations. STEM students exhibited higher proficiency in several skills at the outset of the CL course, indicating distinct strengths in these competencies. Throughout the course, STEM students made significant advancements in all dimensions and specific skills, while non-STEM students did not exhibit significant progress. This discrepancy emphasizes the need for further investigation and potential modifications in the instructional approach to effectively address the learning needs of students enrolled in non-STEM disciplines within the CL context.

Qualitative analysis of students' reflective learning journals provided valuable insights into their experiences within the CL course. Students perceived CL as a method for developing transversal skills and acknowledged its role in fostering communication, teamwork, critical thinking, and cultural understanding. They also highlighted the personal development opportunities afforded by CL, the appreciation and understanding of cultural differences, and the overall positive assessments of the course. These findings reinforce the importance of the CL approach in facilitating skill development and personal growth among students.

Based on the findings and conclusions of the study, the following recommendations for practice could be proposed:

- Adjust instructional approaches for STEM and Non-STEM students: Recognize the differential impact of the VPBL method on students from STEM and non-STEM disciplines. Design instructional approaches that address the specific learning needs of non-STEM students, providing differentiated interventions and additional support to enhance their skill development within the CL context.
- Foster cross-cultural collaboration: Propose courses that take place in cross-cultural collaboration to foster cultural understanding among students. These courses promote an inclusive and respectful learning environment that values diverse perspectives and encourages students to learn from each other's cultural backgrounds.
- Emphasize transversal skill development: Integrate explicit instruction and activities focused on the development of transversal skills within the VPBL. Provide opportunities for students to enhance their communication, teamwork, critical thinking, and problem-solving abilities, as these skills are highly valued in the labor market and essential for future success.
- Continuously assess and provide feedback: Implement ongoing assessment strategies to monitor students' progress in transversal skill development. Regularly provide constructive feedback to students, highlighting areas for improvement and recognizing their achievements. This feedback loop promotes self-reflection, encourages growth, and enhances the overall learning experience.
- Promote self-reflection and metacognitive skills: Incorporate regular opportunities for students to engage in self-reflection and metacognitive practices. Encourage students to maintain reflective learning journals, where they can document

their experiences, challenges, and personal growth throughout the CL course. Facilitate guided reflections to help students become aware of their learning processes, set goals, and develop strategies for continuous improvement.

In conclusion, the present study contributes to the literature by highlighting the significant progress made by students in developing transversal skills through the VPBL method within the CL course. The findings emphasize the need to address the differential impact of CL on students from STEM and non-STEM disciplines and suggest potential modifications to enhance the learning experience and outcomes for non-STEM students.

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