Contemporary Educational Technology, 2025, **17**(1), ep556
ISSN: 1309-517X (Online)

OPEN ACCESS

Research Article

Effect of a teacher training program with ICT on university students' learning

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Citation: Sanhueza, M., Sandoval, L., Ormazabal, M., & Zúñiga, M. (2025). Effect of a teacher training program with ICT on university students' learning. *Contemporary Educational Technology, 17*(1), ep556. https://doi.org/10.30935/cedtech/15745

ARTICLE INFO

Received: 23 May 2024
Accepted: 15 Oct 2024

ABSTRACT

Information and communication technologies (ICT) can help increase teachers' abilities and, as a result, the learning of new cohorts of students who, in the age of mass higher education, enter university classrooms less prepared. Although ICT-based teacher training initiatives are well-known, there is little proof that the results are useful for students. This research aimed to study the efficiency of a teacher preparation program that considered the usage of ICT, with follow-up in the ensuing years. The sample consisted of all students enrolled at the Universidad Tecnológica Metropolitana of Chile from 2017 to 2022. The method of analysis grade point average was compared using a t-test to detect significance each year. The results show that in 2017–2022, students who had courses with trained instructors performed better on tests than students who had classes with untrained teachers on average. Also, it has been found that in science, technology, engineering, and mathematics (STEM) areas instructors receive training that is generally more effective than non-STEM teachers. Consequently, women in STEM and non-STEM fields perform better when their teachers are qualified.

Keywords: ICT and teaching, training's teachers, student and ICT

INTRODUCTION

There is a consensus among specialists regarding the enormous challenges that higher education (HE) has faced in the last four decades in developing countries. The exponential expansion (Marginson, 2016; Quaresma et al., 2022), the tighter control over the use of the resources delivered to the universities, and the demands for effectiveness and quality have put special tension in the usual work of academics and administrators of HE institutions (Kelchen, 2018). Likewise, the provision of funds has gradually decreased, causing a sharp increase in competition for applicants among HE institutions. This phenomenon is observed in developed and developing countries (Wheaton, 2020).

In particular, the growing pressure for results exerted on universities has led to evidence of efficiency indicators such as dropout (Behr et al., 2020) timely graduation (Horn & Lee, 2016; Silvera et al., 2023), and employability (McCowan, 2015; Tran, 2016). To this must be added the regulations of the HE system, which in each country have generated greater demands at the level of results.

For their part, university administrators believe that improving the competitiveness of the efficiency indicators of their institutions depends to a large extent on the result of the teaching-learning process, for

which the professors are ultimately responsible. Hence, the concept of teaching quality is understood about the pedagogical competencies of instructors in HE institutions. The foregoing takes on special importance because instructors require no qualification regarding educational pedagogy, influencing directly the learning environment and thus, students. As some studies show, students perceive these differences between trained teachers and those who are not (Kaynardağ, 2019). In this logic, universities have made great efforts to train their professors in pedagogical techniques, under the hypothesis that this action will improve the learning results of their students (Haarala-Muhonen et al., 2023; Ödalen et al., 2019). It should also be considered that the traditional teaching approach tends to be questioned in terms of its effectiveness when the paradigm of the centrality of the student in the learning processes is installed and with it the exercise of teaching that necessarily requires the use of information and communication technologies (ICT). ICT in this study refers to the infrastructure and components that enable modern computing (Ghavifekr & Razak, 2014; Mendoza et al., 2019; Remache & Belarbi, 2019; Saienko et al., 2020).

The Universidad Tecnológica Metropolitana of Chile has developed a pedagogical training program (hereafter "the training") of more than 100 hours between the years 2017–2021 aimed at teachers from the different programs taught in this institution. The training combines the development of teaching skills and the use of ICT. The achievement of teaching skills is ensured through pedagogical support in the context of practice.

The theoretical framework used in the training is based on both the didactic model (DM) and the international framework for teaching observation and feedback (ISTOF) (Gegenfurtner, 2019; Panayiotou et al., 2021). Although both models originate in primary and secondary education, they are entirely applicable to HE. The DM considers a set of eight variables related to teaching outcomes, which have been empirically tested (Creemers et al., 2013). These variables correspond to the teacher's role in terms of orientation, structuring, teaching modeling, application, time management, and classroom assessment. Meanwhile, the ISTOF model emphasizes assessment, feedback, instructional clarity, classroom climate, classroom management, instructional skills, and long-term planning.

Building on these models, the "diploma in information and communication technologies for teaching" incorporated these aspects into the training of professors, particularly those related to class structuring and adapting to the use of ICT tools. The instructional design (modeling) included a set of dimensions such as assessment, feedback, instructional clarity, classroom climate, classroom management, instructional skills, and long-term planning. Additionally, the diploma program included training in time management and the creation of ICT-enriched learning environments, which are key factors in the DM theory.

One noteworthy aspect is the emphasis on classroom assessment. In our analysis, this is related to an indicator of the impact of teacher training with ICT integration on student learning, as measured by grades (Zhang et al., 2024).

This article reports on an evaluation of the teacher training program developed between 2017 and 2020 at Universidad Tecnológica Metropolitana of Chile, with a follow-up study conducted between 2018 and 2020. Teacher training program in this study refers to the application of a diploma in ICT for university teaching with support The impact of the program was measured on students' learning effectiveness, namely the grades of students enrolled in courses taught by trained teachers, using observational data collected between 2017 and 2021.

LITERATURE REVIEW

The professionalization of teaching in HE has become increasingly pressing, adding to this the requirement of digital skills that they must possess (Esteve-Mon et al., 2020; Land & Gordon, 2015).

According to Diamond and Bulfin (2023), teaching-learning is largely understood as the acquisition of skills, and teaching practice helps students achieve predetermined results. Professionalization is understood as the pedagogical qualification of university professors whose basic training discipline does not contemplate this type of training. Feixas and Lagos (2015) refer indistinctly to teacher development, academic development, or teacher training, to designate the set of training strategies usually planned by university teacher training units

to contribute to the development of skills and pedagogical practices necessary to offer teaching of quality at the university.

The purpose of this action is to increase the effectiveness of the teaching process. In this regard, efforts have been made for some time to establish effective teaching strategies in HE (Devlin & Samarawickrema, 2010). Shaw's (2017) study of the UK experience provides an example of perhaps the most developed attempt to systematize approaches to teacher development, using codified professional standards. The author concludes that training strategies are most effective when applied in the everyday context of practice, using a process-oriented and future-focused approach. In efforts to pedagogically empower teachers in HE, the aim is to promote student learning in such a way that they develop key competencies for successful professional performance (OECD, 2019). On the other hand, a significant part of pedagogical qualification involves incorporating ICT into the teaching-learning process. However, this process has not been without difficulties. For instance, Safar and Qabazard (2019) from Kansas University (KU) point out that despite two decades of massive investment to establish ICT tools as a pivotal tenet of KU's teaching, learning, research, and administration practices, the findings reveal that the formal academic usage of these ICT services and resources by KU faculty is only 'average' (overall mean score is 3.48 [standard deviation (SD) = 0.937] on a 6–point rating scale). This implies that the potential benefits of these academic support ICT systems and services have not been fully realized. Lack of technical support, awareness of availability, time, knowledge/training, and impracticality were among the key factors that led KU faculty members either not to use them at all or to use them infrequently. The above is worrying, since we consider that the 21st century teacher must have digital skills that promote productive and quality pedagogical processes, through the inclusion of technologies in their classes and the use of these tools to promote critical thinking. , the functionality of learning and collaborative work, we have a challenge to overcome (De La Cruz Campos, 2023).

The situation of low formal academic usage of ICT by faculty may have been partly overcome in the context of pandemic-induced remote teaching (Wolhuter & Jacobs, 2021; Yang & Huang, 2021). In a private Colombian university with a competency-based training model, Barbosa and Jaramillo (2019) estimated the relationship between learning style (LS) and ICT use. They found no significant differences between LS and the frequency of ICT use in competency-trained students.

Research indicates that the use of ICT can enhance student achievement. However, despite its importance, there are many examples of the underuse of ICT across all levels of classroom teaching and learning. Previous research suggests that teachers' perceptions, attitudes, and motivation toward ICT play a crucial role in determining its practical use in the classroom. A study in Pakistan measured the effect of university teachers' perceptions, attitudes, and motivation on their readiness to integrate ICT into their classroom teaching. The study concluded that there was a statistically significant effect of university teachers' perceptions, attitudes, and motivation on their readiness to integrate ICT in their classroom teaching. Based on the findings, the study recommends that university teachers with basic ICT literacy should be encouraged to have a positive attitude toward technology use (Zamir & Thomas, 2019).

Overall, the recommendations outlined in this research can help address current challenges associated with the integration of ICT in HE teaching. To facilitate the use and implementation of innovative technologies in HE, it is crucial to reorganize all aspects, including the completeness of education programs, the technological literacy of teachers, and the technical support provided by universities (Tokareva et al., 2019).

In the literature, training programs for HE teachers based on collaboration between teachers and education specialists have been highlighted, with a focus on improving pedagogical practices and competencies to enhance student learning. These programs can go by different names, such as pedagogical advice (Lago & Onrubia, 2008), teaching mentoring (Salazar, 2017), pedagogical mentoring (Fernández-Salinero et al., 2017), and pedagogical accompaniment (Morado, 2017; Morado & Ocampo Hernández, 2018), among others.

Operationally, pedagogical advice to teachers includes the process of monitoring and providing professional pedagogical support through various modalities, including face-to-face, blended, e-learning, and b-learning, either individually or in groups.

There is little empirical evidence at the HE level regarding the impact of teacher training on student learning. The available evaluations are restricted to measuring the satisfaction of the teachers participating

in the improvement, but little is known about the influence of pedagogical practice on students (Norton et al., 2005). Specifically, there is little empirical evidence regarding whether what is learned in teacher training programs is effectively transferred to the classroom, impacting student learning as a result of new pedagogical practices (Feixas & Lagos, 2015).

Teacher training needs to be evaluated to measure its effectiveness. Stes et al. (2010) distinguish two areas of evaluation of university teacher training:

(a) changes in teacher learning: changes in attitudes, concepts, knowledge, and skills and

(b) changes in students, in perceptions, LS, and learning outcomes.

Clarke and Hollingsworth (2002) argue that the level of impact of teacher training on students depends on the context of the development of the subject. Stes et al. (2010) confirm that the characteristics of the training (duration and format) influence the impact.

The evidence provided by Navarro and Verdisco (2000) and Ingvarson (2005) has concluded that training programs based on autonomous and collaborative learning generate more effective results in changing pedagogical practices.

Most of the quantitative studies on the level of impact on students have used the method of differences before and after and a quasi-experimental design (Gibbs & Coffey, 2004). In general, these have reported a positive effect on students' perceptions of teaching.

Finally, in a general review of studies on the pedagogical training of teachers for the use of ICT, most of the studies reviewed did not address the specific effect of the use of ICT on students (Aydın & Gürol, 2019).

CAPACITATION IN ICT FOR UNIVERSITY TEACHING

The model of ICT implementation used in training is fundamentally based on the diffusion of innovation theory (Rogers, 2003) and the RIPPLES model (Chang et al., 2016; Surry et al., 2005). To this effect, the training includes components that encourage peer training and co-learning to develop technological skills. It also stimulates collaboration by creating online courses combined with local technical support, which can assist teacher educators in reaching the required threshold for their ICT proficiency. However, the focus of this process is not just on mastering ICT skills but also on empowering pedagogy and content knowledge and upgrading programs for training teachers (Echols et al., 2018). Teacher educators need to be confident in the added value of ICT. Therefore, the professional development of teacher educators should also focus on the benefits of utilizing ICT to empower teaching and promote pedagogical change (Forkosh-Baruch & Avidov-Ungar, 2019).

The ICT training for university teaching aims to train teachers in the creation of digital educational resources to support student learning. At the end of the training program, teachers should be able to create face-to-face and non-face-to-face learning environments with the support of ICT resources. The training program includes a total of 136 hours of theoretical and practical activities divided into five learning modules. These modules use individual and collective work strategies to increase knowledge in the use of ICT tools to enhance pedagogical skills. Simultaneously, the training program includes the design of a project to resolve a pedagogical problem. The project is addressed by applying active methodologies and ICT tools in the classroom, followed by reflection on the results of the experience in accordance with what is described by other authors (Fedeli & Tailor, 2023).

Specifically, the first and second modules are designed to analyze and reflect on the experience of teachers in their educational training, which allows for a review of the characteristics and possibilities of different ICT tools in the third module and the formulation of an intervention project. In the fourth module, the project is implemented in the classroom, and in the fifth module, there is an instance of reflection for the participant teachers to help make improvements to their subject programs and their implementation.

It is indicated that the training activities are developed on a platform (LMS). This and other platforms allow the program to offer virtual tutorials that are conducted by guest teachers from foreign countries. In this way, teachers who attend the training participate in face-to-face and online activities, which include interventions

Table 1. Participants

Version	Number of participants (UTEM)
2017	59
2018	27
2019	19
2020	29
2021	43

in forums, revision of compulsory readings, and evaluation guidelines. The evidence of the work is recorded on the platform.

On the other hand, the program's accompaniment process covers topics of a pedagogical nature, as well as the use and implementation of ICT activities, and is developed throughout the implementation of the project formulated by each teacher.

The experience gained from the different iterations of the ICT diploma reveals that the accompaniment in the formative process of university teachers is especially valued by teachers since they receive feedback on their practical activities and the use of ICT tools.

Finally, the practical intervention process in the classroom by participant teachers considers that the program specialist accompanies the teachers who implement the intervention in the classroom. This allows for observation, evaluation, and reflection with each teacher about their performance, achievements of their students, and other aspects related to methodologies, pedagogic decisions, resources, and ICT tools applied in the classroom.

The participation of teachers in the training program has been variable. Teachers from other Chilean universities have also joined the program. The evaluation only includes UTEM faculty (**Table 1**).

METHODOLOGY

The data comes from the official records of the University of subjects taken by students and their final status, that is, the grade obtained.

The evaluation methodology used is based on the analysis of the results of the students who enrolled in classes of professors who approved the training program "diploma in information and communication technologies for teaching", versions 2017, 2018, 2019, and 2020 compared with students who enrolled in courses with untrained teachers in those same years.

There is no selection bias in the participants, as long as the students voluntarily register for the subjects without being necessarily informed about the training of their teachers. To capture the effects of the training by minimizing such bias, a comparative analysis of mean differences was used using a test of statistical significance.

Results are compared at the end of training and in subsequent years to detect the persistence of intervention.

The calculations were made using Stata 15.1. The estimations assumed that the teachers applied the use of ICT only in the chosen subject while taking the diploma course and after. The outcome variable is the average grade of subjects for each semester.

FINDINGS

Coverage

A first aspect that must be considered in the analysis of the results of the training program is the coverage of trained professors concerning the total number of professors who teach courses each semester. As can be seen in **Table 2**, coverage fluctuates between 8 and 13.6%. It does not increase systematically, as might be expected for successive cohorts, due to retirements, resignations, and dismissals of some professors.

Table 2. Training coverage per semester

Semester	Training teachers teaching class	Total number of teachers teaching a class	Coverage
2-2017	56	696	8.1%
1-2018	56	785	7.1%
2-2018	73	736	9.9%
1-2019	71	791	9.0%
2-2019	83	752	11.0%
1-2020	86	886	9.7%
2-2020	107	833	12.9%
1-2021	104	799	13.0%
2-2021	106	782	13.6%
1-2022	97	783	12.4%
2-2022	96	751	12.8%

Table 3. Average grade results in students with trained and untrained teachers (1-2016 to 2-2022)

Semester	Non-training teachers	Training teachers	Difference
1-2017	4.51	4.49	.0262
2-2017	4.44	4.54	–.1064***
1-2018	5.03	5.11	–.0807***
2-2018	4.96	5.07	–.1001***
1-2019	5.04	5.08	–.0418***
2-2019	5.17	5.26	–.0874***
1-2020	5.48	5.48	–.0003
2-2020	5.31	5.45	–.1338***
1-2021	5.41	5.44	–.0311***
2-2021	5.34	5.52	–.1745***
1-2022	5.29	5.34	–.0498***

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level

Table 4. Average results of student grades with trained and untrained teachers (2-2017 to 2-2022)

Semester	Non-training teachers	Training teachers	Difference
2-2017	4.45	4.51	–.0635***
1-2018	5.05	5.04	.0074
2-2018	4.97	5.08	–.1116***
1-2019	5.04	5.05	–.0091
2-2019	5.18	5.19	–.0056
1-2020	5.48	5.46	.0202*
2-2020	5.31	5.45	–.1338***
1-2021	5.41	5.44	–.0311***
2-2021	5.34	5.52	–.1745***
1-2022	5.29	5.34	–.0498***
2-2022	5.22	5.24	–.0215

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level

Results at the Student Level

Upon examining the average grades (on a scale of 1–7), it is observed that, in general, trained teachers tend to show better results in their students' grade averages than those who were not trained after the start of their training, except for the semester 1-2020. It is possible that this semester, there may have been an effect of the beginning of the pandemic, as classes started to be taught in a virtual format, generating a distorting effect on the results. It should be noted that in **Table 3**, the column "trained teachers" includes all teachers who, in some semesters, had completed their training. The aim is to verify the persistence of training effects.

Table 4 compares the effect of teacher training in each semester including only teachers who completed the training program before the semester. It should be noted that the training takes place in the first semester of each year. There are significant differences in most of the semesters after the training. Two stages can be

Table 5. Results of the training according to affiliation to STEM or non-STEM

Semester	Non-STEM		Difference	STEM		Difference
	Non-training teacher	Training teacher		Non-training teacher	Training teacher	
2-2017	4.60	4.59	.0077	4.31	4.46	–.1497***
1-2018	5.13	5.01	.1168***	4.97	5.06	–.0850***
2-2018	5.08	5.16	–.0865***	4.86	5.02	–.1555***
1-2019	5.14	5.10	.0325*	4.95	5.03	–.0657***
2-2019	5.28	5.28	.0083	5.10	5.14	–.0480***
1-2020	5.67	5.63	–.0040	5.37	5.34	.0251*
2-2020	5.98	5.68	–.1818***	5.17	5.29	–.1137***
1-2021	5.59	5.69	–.0929***	5.27	5.25	.0283*
2-2021	5.50	5.71	–.2176***	5.22	5.33	–.1105***
1-2022	5.40	5.52	–.1191***	5.18	5.17	.0099
2-2022	5.40	5.39	.0092	5.05	5.12	–.0699***

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level

Figure 1. The difference in average student grades between a trained and untrained teacher (Source: Authors' own elaboration)

distinguished. The first is until 1-2020, in which the effect of the training is evident in the following semester. The second is from 2-2020 in which the favorable effect is more persistent.

Two stages can be distinguished (**Table 5**): the first stage, until 1-2020, where the effect of the training is evident in the following semester, and the second stage, starting from 2-2020, where the positive effect is more persistent

It is of interest to analyze the results of teacher training according to the affiliation of academics to STEM compared to those who are not in STEM. What is observed is that, in general, the training is more effective in STEM teachers than in non-STEM teachers, especially in the first phase until 2-2019. In the second phase, the training is more effective in non-STEM teachers. In this second phase, the training shows results in the STEM field at the end of one semester of training but has a practically neutral effect in the following semester. Such a result could be because the majority of trained teachers lacked pedagogical competencies as a consequence of their disciplinary training and thus made better use of the STEM methodology. However, this is a hypothesis not demonstrated in this research, which remains for future studies.

Finally, to better understand the data, a mixed model was fitted to estimate the difference in semester grade averages between the group of students with trained teachers and non-trained teachers. **Figure 1** shows that training increases the difference between the averages of students with trained and untrained teachers in favor of the former.

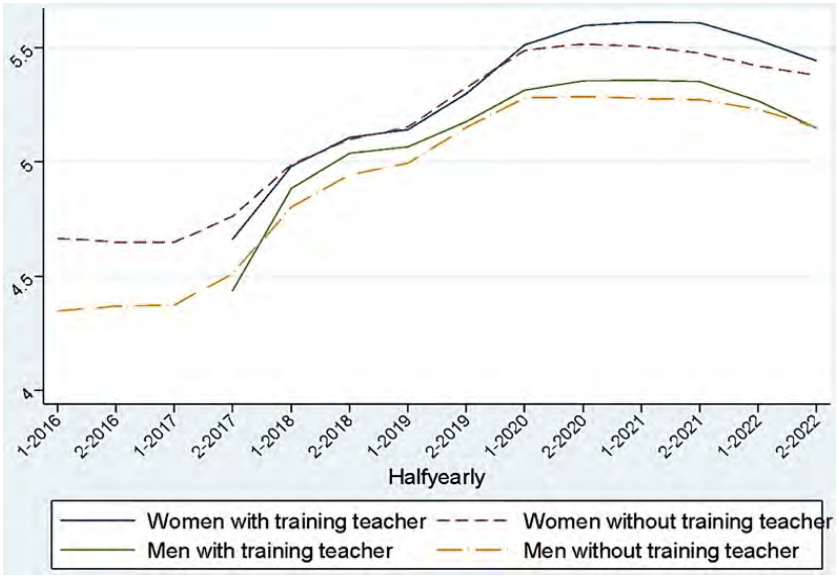

Figure 2. Average grades of women vs. men (Source: Authors' own elaboration)

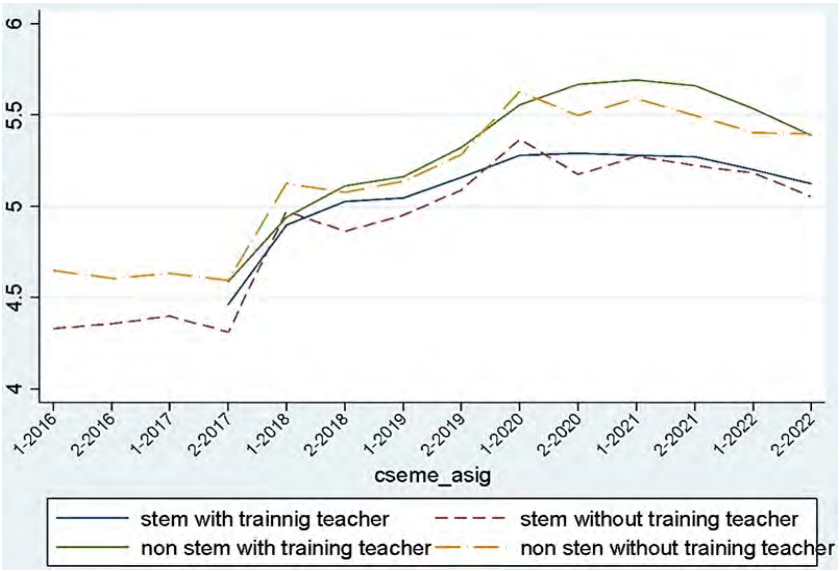

Figure 3. Average grades of STEM vs non-STEM students (Source: Authors' own elaboration)

In a post-estimation analysis, the behavior of grade averages was considered according to the semester, the effect of enrolling in a course with a trained teacher, gender, and STEM affiliation. **Figure 2** shows that women who take courses with trained teachers achieve better averages than women with non-trained teachers, while the performance of men does not show a significant difference between trained and non-trained teachers. Men who take courses with non-trained teachers have the lowest averages. Men with trained teachers perform equally to women with non-trained teachers.

Figure 3 shows that among the non-STEM students, the women get better grades regardless of whether they take subjects with trained teachers or not. However, women who are coursed with trained teachers get better averages.

The comparison leads us to conclude that, in general, the trained teachers obtain better results in both, STEM and non-STEM. However, between men, the training teachers get better results in STEM students.

DISCUSSION

The results show the significant challenge that measuring the impact of pedagogical actions on HE students' learning achievements represents. In this case, the effect of teacher training on student learning outcomes is examined. It should be considered that teacher improvement should focus on the benefits of using technology in teaching and promoting pedagogical change (Forkosh-Baruch & Avidov-Ungar, 2019), rather than as an end in itself. If HE institutions aim to improve teaching, ICT tools are a resource to achieve this (Coudannes & Lossio, 2017).

Actions aimed at modifying teaching practices face various obstacles, such as motivation, commitment, self-critical capacity, willingness to change, and responsibility (Carlos et al., 2017; Pérez Gracia et al., 2022). These aspects should be present in teachers interested in analyzing and improving their teaching practices, as well as those interested in their students' learning (San Martin, 2014).

Considering that virtual teaching characterized the pandemic years worldwide, it developed into an advanced moment on the web, in which alternative virtual spaces to physical spaces had resources to interact, communicate, exchange information, and generate flexible and active learning through technological means (Aguilar, 2020; Cabero et al., 2019; Chong & Marcillo, 2020). Therefore, it was required that university teachers have digital skills, not just motivation, willingness to change, and flexibility in the teaching-learning process.

It is also important to note that teaching practices and their effects on student's learning depend on a set of factors beyond the improvement itself. In this case, fulfilling the condition "ceteris paribus" is extremely difficult. For example, in 2018, teaching practices were disrupted by large feminist mobilizations, in 2019 by social mobilizations, and in 2020 by the COVID-19 pandemic.

Although positive results are evident, it is worth asking why these results do not persist over time. One bias that we were unable to control is spill-over, meaning that teachers who participated in previous versions may have adopted practices that they transmitted to their colleagues. This explanation would be consistent with the fact that these teachers previously had favorable results in their students, which they maintained during and after improvement.

Another contextual situation that should be considered is student protest mobilizations, which tend to disrupt the normal academic calendar. In this sense, it is necessary to point out that in 2018, the end dates of the second semester were moved for the same reason. An even worse situation was experienced at the end of 2019 with the social outbreak in Chile, which forced the abrupt development of remote classes, a precursor to the emergency remote teaching that took place during the pandemic period.

Finally, the results may be limited because the best teachers attend the improvement program before their less-performing colleagues, causing successive versions of teacher training to show lower results.

CONCLUSIONS

It has been verified that the teaching improvement in the "diploma en tecnologías de la información y comunicación para la docencia", 2017 version, improves the grades of the students who enrolled in courses with a trained teacher in some cases. However, significant results persistent over time are not detected, possibly because the control group also consists of teachers with previous pedagogical skills.

In general, the improvement achieves better results with teachers assigned to STEM. Therefore, it is worth asking if it requires refined pedagogical strategies for non-STEM teachers. At the same time, both STEM and NON-STEM women obtain better results when they enroll in courses with trained teachers.

It should also be considered that the constant updating of technological tools requires time for teachers to become familiar with them, an issue that can be addressed through self-training and/or institutionalized improvement programs.

The findings show the difficulties of evaluating the impact of teacher training on student learning. The hypothesis that emerges from the results is that the first version of the improvement attracts the most motivated teachers, but not subsequent ones, which probably decreases the impact of the program over time.

Finally, this study is quantitative; thus, qualitative interviews or focus groups are recommended for further research.

Limitations

The evaluation did not consider improvement that teachers could have acquired in instances other than the Universidad Tecnológica Metropolitana, so presumably, the impact may be greater than that captured in this study. In the same way, effective control against a possible "spillover" by the teachers was not possible.

Author contributions: Conceptualization: MS, LS, MO and MZ; Methodology: LS and MO; Software: LS; Validation: MS, MO and MZ; Formal analysis: LS and MO; Resources: MS; Data curation: MS and LS; Writing—original draft preparation: MO, MZ and LS; Writing—review and editing: MO, MS, MZ and LS; Visualization: MS and LS; Project administration: LS. All authors have read and agreed to the published version of the manuscript.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: The authors declared that this study was exempt from ethical committee approval since it did not include experiments, surveys or interviews with individuals, and it only used administrative data provided by the University. The authors further declared that the study was conducted in accordance with the Declaration of Helsinki.

Declaration of interest: The authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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