# Developing and Validating an Instrument to Measure Students' Perceptions of the use of ICTs and Educational Technologies in Times of the COVID-19 Pandemic

https://doi.org/10.3991/ijet.v17i22.27891

Claudia Galarce-Miranda[1], Diego Gormaz-Lobos[2(✉)],
Steffen Kersten[1], Hanno Hortsch[1]
[1]Technische Universität Dresden, Dresden, Germany
[2]Universidad Autónoma de Chile, Santiago-Talca-Temuco, Providencia, Chile
diego.gormaz@uatonoma.cl

**Abstract—**The main goals of the study were, on the one hand, to develop and validate an instrument to measure students' perceptions of the use of ICTs and educational technologies in times of the COVID-19 pandemic, and on the other hand, to know about the participants' attitudes towards the educational use of ICTs and other educational software. Some specific objectives of the research were (i) to identify the disposition of the students towards the use of ICTs, (ii) to characterize the Interaction with others through the use of ICTs, (iii) to identify the interaction of the students with LMS and ICTs, and to (iv) validate the instrument to measure students' perceptions about the use of ICTs and educational technologies, among others. An in-depth theoretical review allowed the authors of this paper to construct an instrument to measure students' perceptions about the use of ICTs and educational technologies in times of the COVID-19 pandemic. Concerning the statistical analysis, descriptive techniques were used to find out the perceptions of a group of Chilean university students about the online learning process through the use of ICTs, and then, the characteristics of the instrument itself were examined in-depth with exploratory factor analysis. Finally, in order to make the factor analysis more complex and to find proposals for improving the instruments for future research, the percentages of the variables grouped into factors were analyzed, as well as the reliability of each one of them. This research was financially supported by the German Academic Exchange Service (DAAD) as part of the project "Praxispartnerschaften zwischen Hochschulen und Unternehmen in Deutschland und in Entwicklungsländern ab 2017" (Project Nr. 57334905).

**Keywords—**information and communication technologies, university education, online learning in engineering

## 1 Introduction

The 21st century has brought a series of social and structural changes in developing countries that were barely imaginable in the last century. Phenomena such as

globalization, the growing incorporation of technologies in different areas of people's lives, and the development of the so-called information societies, among others, have meant that people increasingly need to incorporate Information and Communication Technologies (ICTs) to be able to participate adequately in the society [1–5].

The Latin American continent has not been exempt from this process. As is well known, this region is mainly conformed by developing countries, and in this matter, one of its major challenges has been to ensure access to technology (ITCs, for instance) and to reduce the gaps in internet access, which has been the main work of the private sector, such as large telecommunications corporations, through the supply of technology and connectivity goods [6–7]. After improving access, countries have begun to consider solutions to reduce the next gap: the need to equip their citizens with competencies and skills that enhance and promote the appropriate use of ICTs. [8–9].

Concerning the proper use of ICTs, the document of the third Ministerial Conference on the Information Society for Latin America and the Caribbean, entitled "ICTs for growth and equality" [10], establishes the importance of the democratic role that ICTs will play in contemporary societies. These issues have been discussed and problematized in academia and in the educational policy guidelines of international organizations for a long time, but never before has it been so urgent the correct implementation of ICTs and educational technologies (ET) as in the context of the COVID-19 pandemic that broke out in the world more than a year ago [9–10]. In this context, technology has emerged as the means to continue with life and participation in society. Technological devices with internet access have been our "vehicle" of transport to work, studies, meetings, shopping, banking, a movie or a concert, and to any other activity that required physical movement.

An in-depth theoretical review of perceptions about the use of ICTs and educational technologies allowed the authors of this paper to construct an instrument to measure students' perceptions about the use of ICTs and educational technologies in times of the COVID-19 pandemic. Concerning the statistical analysis, descriptive techniques were used to find out the perceptions of a group of university students about the learning process through the use of ICTs, and then the characteristics of the instrument itself were examined in-depth with exploratory factor analysis. Finally, the percentages of the variables grouped into factors and the reliability of each variable were analyzed in order to make the factor analysis more complex and also to find proposals for improving the instruments for future research of ICTs at the university context.

### 1.1 Impact of the use of ICTs at university context

The impressive progression in the use of information and communication technologies (ICTs) had an enormous impact on different aspects of the information society, and crucially, on education systems. The responsibility of university education systems seems to be even greater, because they are in charge of "generating and training" the professionals of a society [2, 3, 10]. In the "new" university context, ICTs are decisive as a guarantor of a change towards the higher education model advocated by the Bologna agreement [11]. Sáez indicates that, ideally, university students should be able to work in teams, be creative, contribute ideas, as well as be able to analyze, understand

and discriminate information [7]. In this sense, the same author points out that the use of technology in university education provides resources that make it possible to train professionals who use active methodologies, since, with the possibility of greater access to information, comprehensive and critical learning is encouraged and intellectual production times are improved. Thus, the use of ICTs is intended to enable people to work, learn and study whenever and wherever they want [3, 4, 9].

The impact of the use of ICTs in the university context has been investigated for decades [3–11], as they are not only tools in themselves, but also generate a new social space and, therefore, a new educational space known among others as virtual education [6, 9]. Precisely, virtual education has been presented as an alternative in the historical context originated by the COVID-19 pandemic, which has created an unexpected situation for social structures and their institutions, e.g. for health and education systems [12–14]. In this context, the main response of institutions around the world is to increase the use of e-learning, especially online educational platforms, and videoconferencing rooms. Some university institutions had already been implementing some of these technologies and platforms, but as complementary systems to the face-to-face model [15].

On the other hand, several studies emphasize the essential role that university teachers have concerning online learning [3, 4, 15–22]. The use of ICTs in the educational process is changing how teaching is carried out in universities, as it generates environments that facilitate learning and access to information [20–22]. Some authors suggest that, although teachers need to develop technical skills in these technologies, it is also necessary to have a positive attitude towards these resources [23–24]. In addition, it is necessary to incorporate and manage the ICTs required for each discipline, however, more than their expertise in the use of ICTs [24], what is required is that teachers can guide students towards an interest in developing knowledge and competencies through ICTs [25]. Information societies will constantly aim at technological innovation and, therefore, the role of professionals will be to be lifelong learners in a society in continuous movement, so universities must generate structures and skills to face the challenging social changes.

### 1.2 Use of ICTs at chilean university context

In 2006, the United Nations Development Programme (UNDP) stated that Chile was at the forefront of Latin America concerning the access to the digital era, approaching the connectivity indices of developed countries [26]. These indicators not only reflect the country's efforts to enter the digital era, but also relate to public policies aimed at improving education through ICTs, such as the Programme for Effective Information and Communication Technologies for Education (FONDEF), created at the end of 2002, which aims to promote the development of applied research projects on the use of ICTs to improve learning processes [27–28].

Regarding the use of ICTs by university students, access to computers and smartphones with internet access is almost universal and higher than the rest of the Chilean population. Furthermore, it has been shown that this group uses ICTs primarily to search for information, review content and social networks, and communicate online, using these technological tools for an average of 7 hours a day [29–30].

At the institutional level, Chilean universities have made significant investments in ICTs, such as virtual platforms, learning technologies, and streamlining bureaucratic processes related to university management among others [31]. The use of ICT resources was already advanced before the COVID-19 pandemic, also many postgraduate programs were offered as an online or blended learning modality. These investments and advances in the incorporation of ICTs showed that Chilean students and universities were considered the best prepared educational spaces for online learning in Latin America, but it is important to delve deeper into how this process occurs. In 2018, a study about the use of ICTs at a Chilean private university was published, which demonstrated that, in general, teachers are more proficient in technological aspects than in pedagogical ones. This was the weakest point in the evaluation [32].

These results are related to the distinction of three levels or stages of ICTs incorporation in education: introduction, implementation, and integration [8]. This is because, in the case of Chilean universities (before the pandemic), the incorporation of ICTs was still in the implementation phase. However, the total integration of ICTs in the educational environment is still lacking. This could be explained by the fact that both university institutions and their students seem to be quite advanced in terms of access, management, and use of technology.

This idea was further explored in a study carried out among a group of student teachers at the Faculty of Education of the Universidad Católica del Maule, in Chile, regarding their ICTs skills [33]. This study affirms that there is still work to be done to integrate ICTs, because some difficulties in the integration of ICTs were identified, such as lack of sufficient training by the university teaching staff and its students, a lack of equipment and infrastructure, and there are still difficulties in accessing the internet from home due to geographical (rural) or economic factors. Furthermore, various academic investigations showed that for students, before the COVID-19 pandemic, the use of ICTs was fully integrated into their lifestyles, but not in their use for learning during their university education [33].

## 2 Developing and validating an instrument to measure students' perceptions of the use of ICTs and educational technologies

### 2.1 Methodology

The main goals of the study are to develop and validate an instrument to measure students' perceptions about the use of ICTs and educational technologies in times of the COVID-19 pandemic, and to know about the participants' attitudes towards the educational use of ICTs and other software. The specific objectives of the research are:

1. To identify the disposition (readiness) of the students towards the use of ICTs.
2. To characterize the interaction with others through the use of ICTs.
3. To know about the use of different learning skills with use of ICTs.
4. To identify the interaction of the students with LMS and ICTs.

5. To identify the resources available of the students for the use of ICTs.
6. To validate the instrument to measure students' perceptions about the use of ICTs and educational technologies.

The research has a non-experimental transactional design, characterized by observing phenomena as they occur in their natural context and crystallizing the data collected over time [40].

Based on [3, 5, 7, 9, 11, 17, 23, 25, 29, 30, 34, 42, 43] and their previous experience in research projects about the use of ICTs and the development of a didactical strategy to incorporate educational technologies at the learning process of university students [16, 20, 35, 36, 44, 45], the authors developed a categories system with indicators for the instrument design. The instrument consists of a questionnaire with closed and open-ended questions organized in five main categories with their respective items (see Table 1).

Once the completed questionnaires were received, the students' perceptions of issues related to ICTs in education were analyzed, considering the responses to the 28 items proposed in the instrument. The statistical techniques consisted, firstly in a descriptive analysis of means and standard deviation, and also the analysis of the homogeneity of each variable with corrected item-total correlation [37]. Secondly, the entire scale is subjected to an exploratory factor analysis with principal component analysis and Varimax rotation [38]. As a last procedure, the factors and their internal consistencies are analyzed, investigating their Cronbach's alpha and percentages of responses of grouped variables. All analyses were carried out with the software SPSS.

### 2.2 Population, available sample and procedure

The sample of the research was composed of 137 students from the Faculty of Engineering at a Chilean University. Only 128 questionnaires were considered for the analysis because they were fully completed (nine questionnaires were incomplete). The instrument was applied online, ensuring the anonymity of the participants. The online questionnaires were applied during the second semester of the 2020 academic year. The first part collected information of the participants about gender, engineering fields, entry to engineering programs, and previous experiences with ICTs, among others. The second part consists of the information collection of the closed questions. For the statistical analysis an exploratory-descriptive analysis was applied [39, 40].

### 2.3 Characterization of the sample

In total, 128 students answered fully the questionnaire: 16.41% are women (21) and 83.51% are men (107). Regarding the age ranges of the respondents, 88.28% (113) of the participants are between 21–25 years old, 7.03% (9) are between 26–30 years old, and 4.69% (6) are between 26–30 years old. There are no participants older than 30 years. Related to the participant's distribution by engineering school, most of the participants study industrial engineering (37: 28.91%). The participant's distribution by others engineering schools is: 22.66% (29) from mining engineering, 20.31% (26) from mechanical engineering, 18.75% (24) from computer sciences, and 9.38% (12) from electrical engineering.

## 2.4 Statistical results

The results about the students' perceptions about the use of ICTs and educational technologies are presented in this section. Table 1 exposes the results for the 28 considered items.

**Table 1.** Results of the closed questions

| Items | $\bar{x}$ | S.D | IT-Cr | Low 1–2 | Med. 3 | High 4–5 |
|---|---|---|---|---|---|---|
| 1. I feel prepared for online learning and the use of ICTs. | 3.38 | 0.76 | .609 | 9.4% | 46.9% | 43.8% |
| 2. I am motivated to learn using ICTs. | 3.22 | 1.04 | .386 | 20.3% | 39.1% | 40.6% |
| 3. I am competent in strategies and resources for learning using ICTs. | 3.44 | 0.94 | .701 | 14.1% | 40.6% | 45.3% |
| 4. I find the flexibility of time offered by online learning useful. | 3.86 | 0.90 | .247 | 7.8% | 25% | 67.2% |
| 5. I find the flexibility of space offered by learning with ICTs useful. | 3.77 | 0.85 | .568 | 6.3% | 31.3% | 62.5% |
| 6. Learning with ICTs facilitates interaction with the teacher. | 2.72 | 1.06 | .322 | 42.2% | 32.8% | 25% |
| 7. Learning with ICTs facilitates interaction with other students. | 2.5 | 1.19 | .408 | 56.3% | 18.8% | 25% |
| 8. Group activities are easier thanks to ICTs. | 2.89 | 1.24 | .366 | 39.1% | 29.7% | 31.3% |
| 9. I use different learning strategies (memory, drill, analysis and reflection, synthesis and summarizing, etc.) thanks to ICTs. | 3.73 | 0.86 | .555 | 3.1% | 39.1% | 57.8% |
| 10. I strengthen my learning style (verbal, logical-mathematical, auditory, bodily, visual, interpersonal, and individual or a combination of the above) thanks to ICTs. | 3.78 | 0.93 | .65 | 9.4% | 28.1% | 62.5% |
| 11. Using ICTs I organize my time where it is more effective for me to study. | 3.81 | 0.97 | .616 | 9.4% | 25% | 65.6% |
| 12. Using ICTs, I organize better the timetables where it is more effective for me to do university work. | 3.7 | 0.92 | .639 | 7.8% | 32.8% | 59.4% |
| 13. I improve the length of my concentration time using ICTs. | 3.61 | 1.16 | .602 | 15.6% | 28.1% | 56.3% |
| 14. The work and study timetable is strengthened by using ICTs. | 3.44 | 1.14 | .55 | 18.8% | 32.8% | 48.4% |
| 15. I plan my work and study week better thanks to ICTs. | 3.67 | 1.14 | .61 | 20.3% | 15.6% | 64.1% |
| 16. I know how to search for relevant information using ICTs. | 4.02 | 0.93 | .526 | 6.3% | 18.8% | 75% |
| 17. I know how to organize the information I find in ICTs. | 4.06 | 0.77 | .533 | 3.1% | 17.2% | 79.7% |

*(Continued)*

**Table 1.** Results of the closed questions *(Continued)*

| Items | $\bar{x}$ | S.D | IT-Cr | Low 1–2 | Med. 3 | High 4–5 |
|---|---|---|---|---|---|---|
| 18. I can distinguish between relevant and irrelevant information in ICTs. | 4.02 | 0.86 | .617 | 6.3% | 17.2% | 76.6% |
| 19. I am proactive in responding to new ICTs learning tasks. | 3.81 | 0.83 | .701 | 4.7% | 31.3% | 64.1% |
| 20. I feel more responsible for my own learning process using ICTs. | 4.06 | 0.85 | .524 | 4.7% | 18.8% | 76.6% |
| 21. I have a computer, phone, tablet, etc. permanently available for learning. | 4.19 | 1.32 | .447 | 14.1% | 12.5% | 73.4% |
| 22. I have all the software and programs for learning. | 4.16 | 1.01 | .566 | 4.7% | 20.3% | 75% |
| 23. I have access to the Internet for learning. | 4.25 | 0.99 | .323 | 6.3% | 20.3% | 73.4% |
| 24. I consider that the costs (food, maintenance, transport, etc.) for learning with ICTs have increased compared to when they are not used. | 3.05 | 1.37 | .39 | 40.6% | 21.9% | 37.5% |
| 25. I consider that the costs of requirements (technology, internet, software, books, etc.) for my training have gone up. | 3.94 | 1.2 | .255 | 15.6% | 14.1% | 70.3% |
| 26. The university supports positively the use of ICTs for learning. | 3.91 | 1 | .429 | 7.8% | 21.9% | 70.3% |
| 27. In my family, the use of ICTs for learning is positively supported. | 3.75 | 1.22 | .322 | 18.8% | 18.8% | 62.5% |
| 28. In my group of friends, the use of ICTs for learning is viewed positively. | 3.83 | 1.14 | .56 | 15.6% | 18.8% | 65.6% |

*Notes:* N is equal for all (128) and 20 of the items reach the minimum (1) and maximum (5) value, except for items 4, 5, 10, 17, 18, 19, 20 and 23 where the minimum value (2). $\bar{x}$ = Mean; S.D. = Standard Deviation; IT-Cr= Corrected item-total correlations.

In general, the results show a high percentage of agreement with the following statements that refer to students' ICTs skills: students state that they know how to organize information (79.7%), distinguish between relevant and irrelevant information in ICTs (76.6%), and are proactive in responding to new learning tasks with ICTs (64.1%). (64.1%). They also report feeling more responsibility for their own learning process using ICTs (76.6%). In terms of access, the majority of students report having a computer, telephone, or tablet for learning at all times (73.4%), with all the software and programs for learning (75%), and with access to Internet (73.4%). However, it is striking that despite the high percentage who report having access, there is still a significant percentage who say that they do not have permanent tools to make use of ICTs (14.1%). Related to this issue, most of the students perceive that the costs of requirements (technology, internet, software, books, etc.) for their training have increased (70.3%), but this has not been the case with the perception that the costs of food, maintenance and transport have increased (40.6%).

On the other hand, there are those items that evaluate the support network for the use of ICTs, where students perceive that their university (70.3%) and their families (62.5%) positively support the use of ICTs for learning, as well as their group of friends positively view their use of ICTs for learning (65.6%). Despite the high percentages of these variables, there is still a significant percentage who state that they do not receive positive support from their family in the use of ICTs (18.8%).

As for the spatial-temporal benefits of learning through ICTs, the students perceive the flexibility of time (67.2%) and space (62.5%) offered by learning with ICTs as useful. Most of them state that with the use of ICTs they can better organize the times when it is most effective for them to study (65.6%) and when it is most effective for them to do university work (59.4%), as well as allowing them to better plan their work and study week (64.1%), and to a lesser but significant extent, they recognize that work and study schedules are strengthened with the use of ICTs (48.4%).

### 2.5 Results of the factor structure analysis

In order to evaluate the structure of the questionnaire from the scores of the items that compose it, exploratory factor analysis was applied for the complete scale that seeks to find out the students' perceptions regarding the use of ICTs. The factor analysis was carried out with principal component extraction and subsequent Varimax rotation with Kaiser [38]. For the exploratory factor analysis, values lower than .40 are suppressed so that the results do not show values of factor loadings lower than this value and to make it clearer which are the most important loadings and which are not, since quantities lower than this value are considered to discriminate poorly [37]. The sample adequacy measures show us that the factor analysis is relevant given the high KMO index of the scale (0.757), which being greater than 0.75 would be fine [41]. On the other hand, Bartlett's test of sphericity, which assesses the applicability of factor analysis, has a significant index of 0.000, so factor analysis can be applied [38, 41].

An iterative process of factor analysis was carried out and in each case items whose factor loadings were weak or saturated on more than one factor were eliminated. The items eliminated in the factor analysis scale were: 1, 14, 17, 26, 28.

The Cronbach's alpha measure for the full scale entering the factor analysis is .884. Table 2 presents the resulting factor structure after eliminating the items listed above.

**Table 2.** Result of the exploratory factor analysis

| Items | Factor | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **12** | .868 | | | | |
| **11** | .814 | | | | |
| **13** | .788 | | | | |
| **10** | .770 | | | | |
| **15** | .729 | | | | |
| **9** | .692 | | | | |
| **3** | .683 | | | | |
| **18** | .669 | | | | |
| **16** | .651 | | | | |
| **19** | .625 | | | | |
| **20** | .408 | | | | |
| **6** | | .857 | | | |
| **8** | | .813 | | | |
| **7** | | .810 | | | |
| **25** | | | .888 | | |
| **27** | | | .872 | | |
| **24** | | | .762 | | |
| **21** | | | | .844 | |
| **23** | | | | .797 | |
| **22** | | | | .732 | |
| **5** | | | | | .799 |
| **4** | | | | | .789 |
| **2** | | | | | .620 |

Table 2 shows the result of the exploratory factor analysis; the 23 items entered are grouped into 5 factors. The Kaiser rule provides a factor structure with five factors that explain 68.32% of the total variance.

The first factor refers to "students skills and ICTs potentialities for learning" and is composed of 11 items that explain 25.11% of the total variance. Cronbach's alpha for this factor is 0.92. It can be seen that for the students this factor concentrates variables with high percentages of agreement, where the students' characteristics and the potential of ICTs in learning are recognized. However, there are also significant percentages that do not agree with the statements about mastering ICTs strategies and resources (14.1%), time planning better thanks to ICTs (20.3%), and evaluating an improvement in concentration using these tools (15.6%).

A second factor is made up of 3 items that refer to "social interaction in the use of ICTs" and explains 11.44% of the total variance. Cronbach's alpha for this factor is 0.83. Table 2 shows the three items that make up this factor, where it can be seen that the responses are concentrated in low levels of agreement with the statements that

indicate that: learning through ICTs facilitates interaction with the teacher (42.2%), with other students (56.3) and group activities through these media are easier (39.1%).

The third factor refers to "family support and costs for learning through ICTs" which explains 11.25% of the variance and consists of 3 items. Cronbach's alpha for this factor is 0.83. This factor shows that the students consider that the costs of food, maintenance, and transport have not increased with the use of ICTs (40.6%), but that the costs of technology, software, etc. have increased (70.3%). This factor shows that most families positively support the use of ICTs (62.5%). However, it is striking that a significant percentage of the respondents do not perceive this support (18.8%).

The fourth factor refers to "access to ICTs" and explains 10.4% of the variance. It is made up of 3 variables that have a Cronbach's alpha of 0.78. For this factor, it can be observed that the variables have high percentages; however, there is a significant percentage in the variable concerning the permanent availability of ICTs (14.1%).

And finally, the fifth factor refers to "Motivational predispositions in the use of ICTs" explaining 10.13% of the variance. Cronbach's alpha for this factor is 0.77. This factor groups 3 variables that talk about the perceived usefulness of ICTs and the motivation to learn with it. Thus, it is observed that the behavior of this factor indicates that it is recognized that learning through ICTs is useful to make time and space more flexible (67.2%), and to a lesser extent, it is mentioned that it is motivating to learn through ICTs (40.6%).

## 3 Discussion and conclusion

The main goals of the study were to develop and validate an instrument to measure students' perceptions about the use of ICTs and educational technologies in times of the COVID-19 pandemic, and to know about the participants' attitudes towards the educational use of ICTs, and other software at a Chilean university.

In the specialized literature, three levels or phases of ICTs incorporation in education systems can be distinguished: introduction, implementation, and integration [8]. The descriptive analyses show that the implementation phase is indeed at an advanced stage; however, it does not yet seem to be in the integration phase, because the variables grouped in Factor 4, which allude the access to the internet and technologies, are those with the highest percentages in the instrument. However, some indicators show that access is still not universal, since, when asked about the permanent availability of ICTs for their studies, 14.1% of students still say that they do not have them permanently. This situation is reinforced by the variables asking about positive family support for learning through ICTs (to assess the implementation phase), where 18.8% say that they do not have this support. This variable could be strongly related to the variable in Factor 3, which indicates that students consider that the costs of requirements for learning with ICTs have increased (70.3%). According to this information, it is possible to infer that there is a family factor (and maybe also an economic factor) that could produce some difficulties to face this change in the learning modality. It is possible to refer to factors specific to the household, such as, for instance, having technological devices with sufficient internet connectivity for the family members or spatial issues, such as an exclusive space for study.

Thanks to the factor analysis, it is possible to identify that there are still variables that would be useful to add in a future instrument that deals with these issues in depth. In this sense, it could be interesting to study what is the infrastructure available for study (at home), what are the dynamics within this space, whether they facilitate or promote concentration, respect, and silence, etc. On the other hand, there are high percentages of agreement in those variables that evaluate the characteristics of the students and the potential for learning through ICTs (Factor 1), where it is evident that the students have all the tools for this process to be integrated quickly, as they not only use ICTs several hours a day but also know how to use them for educational purposes.

In this sense, students are able to discriminate the information they find, to support academic studies through them and to recognize the potential of ICTs (they recognize that the length of their concentration time has improved, that their work and study timetable has been strengthened and that they plan their work and study week better).

However, the theory has also pointed out how important motivational aspects are in the successful integration of this type of learning. The role of teachers and the importance of having technical competencies, but also a positive attitude towards technological resources are also mentioned [16, 18, 23, 24, 25]. This can be applied to the case of learners, where the instrument has shown that students are technically good with ICTs for learning (Factor 1), but the results show that particular attention needs to be paid to the motivational aspects (Factor 5). In this factor (5), the students recognize that this learning method is useful for making time (67.2%) and space (62.5%) more flexible. In addition, they recognize, to a lesser extent, that learning through ICTs is something that motivates them (40.6%). However, as this factor is the one with the least internal variation and least reliability, it would be necessary to extend the instrument for future research and add more questions that investigate especially the emotional aspect of this type of learning. In relation to this, various theoretical approaches point to the importance of social factors in learning through ICTs, where ICTs are necessary to encourage encounters, such as virtual platforms or discussion forums so that the social nature of learning is not lost. These research results correspond to Factor 2, which deals with social relations in the use of ICTs, showed the lowest levels of agreement with these indicators, indicating that learning through ICTs does not facilitate interaction with the teacher (42.2%), with other students (56.3%) and that group activities through these media are not necessarily easier (39.1%). This shows that this factor needs to be addressed to improve the learning process with the integration of ICTs. In this sense, it shows also the need to improve the measurement instruments, because only one question specifically addresses the relationship with the teacher (and it was here poorly assessed). On the other hand, theory indicates the importance of teachers successfully integrating ICTs into teaching-learning activities, so it would be important to investigate this aspect in future research.

The authors of the present research are aware of the exceptional context caused by the COVID-19 pandemic that has led to the rapid incorporation of ICTs in university education, but they believe that the integration of ICTs in educational systems will continue to be necessary due to their many benefits and the flexibility they offer for further learning both formally and informally.

## 4 Acknowledgment

This paper was written as part of the research project "Strengthening engineering training at Chilean universities through practice partnerships", STING Project (in Ger-man "Stärkung der Ingenieurausbildung an chilenischen Hochschulen durch Prax-ispartnerschaften") financially supported by German Academic Exchange Service (DAAD) as part of the project "Praxispartnerschaften zwischen Hochschulen und Unternehmen in Deutschland und in Entwicklungsländern ab 2017" (Project Nr. 57334905).

## 5 References

[1] Thompson, K. M. & Copeland, C. A. (2020). Inclusive considerations for optimal online learning in times of disasters and crises. Information and Learning Sciences, Special Issue: A Response to Emergency Transitions to Remote Online Education in K-12 and Higher Education. https://doi.org/10.1108/ILS-04-2020-0083

[2] United Nations (2020). Policy brief: Education during COVID-19 and beyond. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/sg_policy_brief_covid-19_and_education_august_2020.pdf

[3] Razak, N., Ab Jalil, H. & Ismail, I. (2019). Challenges in ICT integration among Malaysian public primary education teachers: The roles of leaders and stakeholders. International Journal of Emerging Technologies in Learning, 14(24): 184–205. https://doi.org/10.3991/ijet.v14i24.12101

[4] Tambunan, H., Silitonga, M. & Sidabutar, U. B. (2021). Online and face-to-face composition in forming the professional competencies of technical teacher candidates with various learning style types. Educ Inf Technol 26, 2017–2031. https://doi.org/10.1007/s10639-020-10349-3

[5] Yunus, M. M. & Salehi, H. (2012). The effectiveness of facebook groups on teaching and improving writing: Students' perceptions. Int. J. Educ. Inf. Technol., 1(6): 87–96.

[6] De la Selva. R. (2014). Los nuevos rostros de la desigualdad en el siglo XXI: La brecha digital. Revista Mexicana de Ciencias Políticas y Sociales. 60(223): 265–285. https://doi.org/10.1016/S0185-1918(15)72138-0

[7] Sáez López, J. M. (2012). Integración práctica de la tecnología educativa en el grado de educación social. Edutec. Revista Electrónica De Tecnología Educativa, 40. https://doi.org/10.21556/edutec.2012.40.369

[8] De Pablos Pons, J., Colás Bravo, P. & González Ramírez T. (2010). Factores facilitadores de la innovación con TIC en los centros escolares. Un análisis comparativo entre diferentes políticas educativas autonómicas. Revista de Educación, 352: 23–51. https://doi.org/10.15581/004.20.4462

[9] Durán R., Estay-Niculcar, C. & Álvarez H. (2015). Adopción de buenas prácticas en la educación virtual en la educación superior. Aula Abierta 43(2): 77–86. https://doi.org/10.1016/j.aula.2015.01.001

[10] CEPAL (2010). Las TIC para el crecimiento y la igualdad: Renovando las estrategias de la sociedad de la información. Unión Europea: CEPAL. https://www.cepal.org/es/publicaciones/2971-tic-crecimiento-la-igualdad-renovando-estrategias-la-sociedad-la-informacion

[11] Martínez-Galianoa, J. M., Pena, P., Gálvez-Toro. A. & Delgado-Rodríguez, M. (2016). Metodología basada en tecnología de la información y la comunicación para resolver los nuevos retos en la formación de los profesionales de la salud. Educación Médica, 17(1): 20–24. https://doi.org/10.1016/j.edumed.2016.02.004

[12] World Bank (2020). Remote learning and COVID-19. http://documents1.worldbank.org/curated/en/266811584657843186/pdf/Rapid-Response-Briefing-Note-Remote-Learning-and-COVID-19-Outbreak.pdf; https://doi.org/10.1596/33479

[13] Zhang, W., Wang, Y., Yang, L. & Wang, C. (2020). Suspending classes without stopping learning: China's education emergency management policy in the COVID-19 outbreak. Journal of Risk and Financial Management, 13(3): 113–115. https://doi.org/10.3390/jrfm13030055

[14] Kapasia, N., Paul, P., Roy, A., Saha, J., Zaveri, A., Mallick, R., (…) & Chouhan, P. (2020). Impact of lockdown on learning status of undergraduate and postgraduate students during COVID-19 pandemic in West Bengal, India. *Children and Youth Services Review*, 116, Article 105194. https://doi.org/10.1016/j.childyouth.2020.105194

[15] Hodges, C., Moore, S., Lockee, B., Trust, T. & Bond, A. (2020). The difference between emergency remote teaching and online learning. Educause Review. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-andonline-learning

[16] Gormaz-Lobos, D., Galarce-Miranda, C., Hortsch, H. & Vargas-Almonacid, C. (2021). Teacher training's needs in university context: A case study of a chilean university of applied sciences. International Journal of Emerging Technologies in Learning 16(9): 119–132. https://doi.org/10.3991/ijet.v16i09.21389

[17] Elas, N. I. B., Abd Majid, F. B. & Suthagar, A. (2019). Development of technological pedagogical content knowledge (TPACK) for english teachers: The validity and reliability. International Journal of Emerging Technologies in Learning, 14(20): 18–33. https://doi.org/10.3991/ijet.v14i20.11456

[18] Matviyevskaya, E. G., Tavstukha, O. G., Galustyan, O. V., Ignatov, P. A. & Miroshnikova, D. V. (2019). Formation of information and communication competence of future teachers. International Journal of Emerging Technologies in Learning, 14(19): 65–76. https://doi.org/10.3991/ijet.v14i19.10990

[19] Hrmo, R., Miština, J. & Krištofiaková, L. (2016). Improving the quality of technical and vocational education in slovakia for european labour market needs. International Journal of Engineering Pedagogy, 06(2): 14–22. https://doi.org/10.3991/ijep.v6i2.5369

[20] Gormaz-Lobos D., Galarce-Miranda C., Hortsch H. & Kersten S. (2020). The needs-oriented approach of the dresden school of engineering pedagogy and education. In: Auer M., Hortsch H., Sethakul P. (Eds.) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. Advances in Intelligent Systems and Computing, 1134: 589–600. https://doi.org/10.1007/978-3-030-40274-7_56

[21] Dıaz, M., Gormaz-Lobos, D. Galarce-Miranda, C., Valenzuela, F., Rojas, F., Duran, A., Cerda, C., Carrasco, D. & Hortsch, H. (2020). Strengthening the training of engineers in Chilean universities through practice partnerships: STING Project, Procedia Computer Science, 172: 597–602. http://www.sciencedirect.com/science/article/pii/S1877050920314058; https://doi.org/10.1016/j.procs.2020.05.076

[22] Almetov, N., Zhorabekova, A., Sagdullayev, I., Abilhairova, Z. & Tulenova, K. (2020). Engineering education: Problems of modernization in the context of a competence approach. International Journal of Engineering Pedagogy, 10(6): 7–20. https://doi.org/10.3991/ijep.v10i6.14043

[23] Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E. & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. Computers & Education, 59(2): 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

[24] Pedraza, N., Farías, G., Lavín J. & Torres, A. (2013). Las competencias docentes en TIC en las áreas de negocios y contaduría Un estudio exploratorio en la educación superior. Perfiles Educativos, 35(138): 8–24. https://doi.org/10.1016/S0185-2698(13)71806-3

[25] Zulkarnayeva, Z. (2021). Teachers' views on the use of information and communication technologies (ICT) in education environments. *International Journa of Emerging Technologies in Learning*, 16(03). https://doi.org/10.3991/ijet.v16i03.18801

[26] United Nations Development Programme (2006). Informe sobre Desarrollo Humano en Chile. Las nuevas tecnologías: ¿un salto al futuro? Santiago de Chile: PNUD. https://www.estudiospnud.cl/informes-desarrollo/informe-sobre-desarrollo-humano-en-chile-2006-las-nuevas-tecnologias-un-salto-al-futuro/

[27] Claro, M. & Y Jara, I. (2020). The end of enlaces: 25 years of an ICT education policy in Chile. Digital Education Review, (37): 96–108. https://doi.org/10.1344/der.2020.37.96-108

[28] Claro, M., Preiss, D., San Martín, E., Jara, I., Hinostroza, J., Valenzuela, S., Cortes, F., & Nussbaum, M. (2012). Assessment of 21st century ICT skills in Chile: Test design and results from high school level students, Computers & Education, 59(3). https://doi.org/10.1016/j.compedu.2012.04.004

[29] Labbé, C., López-Neira, L., Saiz, J., Vinet, E. & Boero P. (2019). Uso de TIC en estudiantes universitarios chilenos: Enfoque desde la adultez emergente. Pensamiento Educativo. Revista de Investigación Educacional Latinoamericana, 56(2): 1–14. https://doi.org/10.7764/PEL.56.2.2019

[30] Claro, M., Salinas, A., Cabello-Hutt, T., San Martín, E., Preiss, D. D., Valenzuela, S. & Jara, I. (2018). Teaching in a digital environment (TIDE): Defining and measuring teachers' capacity to develop students' digital information and communication skills. Computers & Education, 121, 162–174. https://doi.org/10.1016/j.compedu.2018.03.001

[31] Araya-Castillo, L., Jiménez Bucarey, C. G., Barrientos Oradini, N., Flores, Y., Yáñez Jara, V. & Contreras Barraza, N. (2021). Importancia de la calidad de servicio en la Educación superior a distancia. Arandu UTIC, 7(2). http://www.utic.edu.py/revista.ojs/index.php/revistas/article/view/117

[32] Ríos, J. M., Gómez, E. R. & Rojas, M. P (2018). Valoración de competencias TIC del profesorado universitario: Un caso en Chile. Píxel-Bit. Revista de Medios y Educación, (52) 55–65. https://doi.org/10.12795/pixelbit.2018.i52.04

[33] Cerda-Diaz, L. (2017) TIC skills in pedagogy students of the Catholic University of Maule. Procedia - Social and Behavioral Sciences, 237, 893–899. https://doi.org/10.1016/j.sbspro.2017.02.125

[34] Papadakis, S., Kalogiannakis, M., Sifaki, E. & Vidakis, N. (2018). Evaluating Moodle use via Smart Mobile Phones. A case study in a Greek University. EAI Endorsed Transactions on Creative Technologies, 5(16). https://doi.org/10.4108/eai.10-4-2018.156382

[35] Galarce-Miranda C., Gormaz-Lobos D., Hortsch H. & Kersten S. (2021). Design and implementation of the international center of engineering education at the university of talca (Chile) under IGIP and the dresden school of engineering pedagogy tradition. In: Auer M.E., Rüütmann T. (eds) Educating Engineers for Future Industrial Revolutions. ICL 2020. Advances in Intelligent Systems and Computing, 1329. Springer, Cham. https://doi.org/10.1007/978-3-030-68201-9_2

[36] Gormaz-Lobos D., Galarce-Miranda C., Hortsch H. & Kersten S. (2020). Engineering pedagogy in chilean context: some results from the PEDING-Project. In: Auer M., Hortsch H., Sethakul P. (eds) The Impact of the 4th Industrial Revolution on Engineering Education. ICL 2019. Advances in Intelligent Systems and Computing, 1135. Springer, Cham. https://doi.org/10.1007/978-3-030-40271-6_11

[37] Nunnally, J. & Bernstein, Y. (1995). Teoría psicométrica. México: McGrawHill.

[38] Romero, S. J. y Ordoñez, X. G. (2015). Psicometría. Madrid, España: COYVE S.A.

[39] Cohen, L., Manion, L. & Morrison, K. (2013). Research methods in education. Routledge, Londres. https://doi.org/10.4324/9780203720967
[40] Hernández, R., Fernández, C. & Baptista, P. (2014). Metodología de la investigación. (6ª. ed.). México: McGraw Hill Interamericana.
[41] De la Fuente, S. (2011). Análisis factorial. Facultad de Ciencias económicas y empresariales. Universidad Autónoma de Madrid.
[42] Matviyevskaya, E. G., Tavstukha, O. G., Galustyan, O. V., Ignatov, P. A. & Miroshnikova, D. V. (2019). Formation of information and communication competence of future teachers. International Journal of Emerging Technologies in Learning, 14(19): 65–76. https://doi.org/10.3991/ijet.v14i19.10990
[43] Means, B., Bakia, M. & Murphy, R. (2014). Learning online: What research tells us about whether, when and how. New York: Routledge. https://doi.org/10.4324/9780203095959
[44] Riahi, S. & Riahi, A. (2018). The pedagogy of higher education: How to evaluate the quality of training in morocco to improve it. International Journal of Engineering Pedagogy, 8(1): 92–108. https://doi.org/10.3991/ijep.v8i1.7984
[45] Oliveira, A., Feyzi Behnagh, R., Ni, L., Mohsinah, A. A., Burgess, K. J. & Guo, L. (2019). Emerging technologies as pedagogical tools for teaching and learning science: A literature review. Hum Behavior & Emerging Technology, 1(2): 149–160. https://doi.org/10.1002/hbe2.141

## 6 Authors

**Dr. phil. Claudia Galarce-Miranda.** Dr. Galarce-Miranda studied Education (B.A) at the Pontificia Universidad Católica de Chile. She studied a Master program in Education with a specialization in Education Research at the Technische Universität Dresden (Germany). Between 2012 and 2014 she worked as a Research Assistant in a project dedicated to the development of digital learning platforms at the Technische Universität Dresden. She completed a Ph.D. program at the Freie Universität Berlin, Germany. Dr. Galarce-Miranda works since 2014 as a Research Associate of the Faculty of Education and since 2021 works at the Center for Open Digital Innovation and Participation (CODIP) at the Technische Universität Dresden.

**Dr. phil. Diego Gormaz-Lobos.** Dr. Gormaz-Lobos formerly studied Education (B.A) at the Pontificia Universidad Católica de Chile. He completed a Master Degree and a Ph.D. program in Education at the Technische Universität Dresden (Germany) specializing in university and technical education. Between 2014 and 2020, Dr. Gormaz-Lobos worked as a Research Assistant at the Technische Universität Dresden, Faculty of Education. Diego is currently part of the research staff of the Universidad Autónoma de Chile, Faculty of Engineering.

**Dr. phil. Steffen Kersten** is a Dipl. Ing. Päd. Elektrotechnik who obtained a Ph.D. in Vocational Pedagogics, Didactice and Methodics. Presently, Dr. Kersten serves as the Vice-President of IPW (Scientific Society for Engineering Education, Germany) and he also serves in to the Chair for Didactics of Vocational and Professional Learning and Teaching Education at the Technische Universität Dresden (Germany). Since the 1990s, he has been involved with a multitude of professional research projects in engineering pedagogy and education in 28 countries and presently is involved with programs in China, Chile, Germany and Kenya.

**Prof. Dr. paed. habil. Hanno Hortsch** is an electro-mechanic who obtained a Ph.D. in Sciences, Methodology and a Ph.D. in Vocational Pedagogics, Didactice and Methodics. Presently, Dr. Hortsch serves as the President of the IGIP and as the Director of the IGIP Training Institute Dresden. He also serves as the Chair for Didactics of Vocational and Professional Learning and Teaching Education at the Technische Universität Dresden. Prof. Dr. Hortsch was selected as the 2017 recipient of the IFEES Duncan Fraser Global Award for Excellence in Engineering Education. He has decades of experience in engineering education and has played a pivotal role in pedagogical development in Germany and abroad.

Article submitted 2021-10-27. Resubmitted 2022-10-19. Final acceptance 2022-10-19. Final version published as submitted by the authors.