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Educational Technologies and Their Application to Music Education: An Action-Research Study in an Ecuadorian University

Oscar-Elías Bolívar-Chávez ¹, Joaquín Paredes-Labra ^{2,*} , Yury-Vladimir Palma-García ³
and Yessenia-Anabel Mendieta-Torres ³

¹ Didactics Department, Universidad Técnica de Manabí, Portoviejo 130105, Ecuador; oscar.bolivar@utm.edu.ec

² Didactics Department, Universidad Autónoma de Madrid, 28049 Madrid, Spain

³ Arts Department, Universidad Técnica de Manabí, Portoviejo 130105, Ecuador;
yury.palma@utm.edu.ec (Y.-V.P.-G.); ayessenia@utm.edu.ec (Y.-A.M.-T.)

* Correspondence: joaquin.paredes@uam.es

Abstract: Information and Communication Technologies (ICT) are tools that are part of the process of teaching and learning music. These didactic/pedagogical resources are widely used by teachers. They strengthen, motivate, and increase the student's interest in learning. This study is an action-research (AR). It involves 12 teachers and 68 students in the subject of music education in an Ecuadorian university. A Holistic and Technological Model of Music Education (HTMME) was generated. The performance of the plan was evaluated by means of an original questionnaire and qualitative work. The AR procedure involved an analysis of data at the end of each implementation cycle. The appreciation of the new model was very positive. With the methodology implemented, new teaching experiences and relevant learning for students were achieved. Learning music with ICT induces creative-musical processes in students.

Keywords: ICT; innovation; musical software; music language; educational enhancement



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1. Introduction

Information and Communication Technologies (ICT) are techniques, developments and devices (software and hardware), information carriers, and communication channels that integrate functionalities of storage, processing, and transmission of digitized information [1].

With ICT, a change has been cultivated in today's higher education. The teacher can be an architect and mediator of knowledge [2] and the student a builder of a whole amalgam of wisdom [3]. The implementation of music with ICT allows a great change in musical creation [4]. Advances are produced in the practices of composition and musical creation as stated below. These practices can be brought into the processes of teaching and learning [5].

1.1. Uses of ICT in Music Education

With the use of ICT, new educational scenarios emerge.

In the current context, teaching music during a pandemic period is forcing academic institutions to quite different pedagogical solutions. Teachers are generally satisfied with the mainstream online learning platforms. Resource delivery, instructional management, assignment collection and grading, multi-terminal accessibility, and ease of use are well appreciated [6]. However, some studies favor autonomous learning, with collaborative projects, affective support, and short online meetings [7]. In the last context, music students begin as online performers in very creative activities [8,9]. Software solutions are contributing to support these learning environments. With the use of ICT, different information formats can be made available and used in the teaching-learning process. Some resources

that the teacher should have knowledge of are virtual encyclopedias, online databases, web 2.0 tools, videos, and other multimedia available on platforms such as YouTube or Slideshare. Didactic/pedagogical resources generated with the help of ICT are reusable and distributable [10]. Teachers share all of them through storage devices and the Internet. In addition, with ICT it is possible to participate in collaborative work in professional networks. In this way, teachers and students update their knowledge. Many teachers around the world use ICT to share their classroom experiences and resources. The purpose of teaching with ICT is not the use of the resource, but the learning that the student can obtain with it [11]. Research on their practices has become a recent trend to understand how educators might realize productive and meaningful collaborations with researchers, and how researchers might envisage teachers as important contributors to research project conception, design, implementation, interpretation, and application. Involving students could be fundamental [12].

To take advantage of these resources, digital skills are essential for students and teachers. Students' digital competence implies the critical and safe use of ICT for work, leisure, and communication. It relies on basic ICT skills: using computers to retrieve, assess, store, produce, present, and exchange information as well as to communicate and participate in collaborative networks over the Internet [13,14].

In a complementary way, teachers must know how to take advantage of the educational resources available in the media and the web with their students [4]. For many teachers, music is considered a pedagogical strategy to expand both diverse knowledge and the creative capacity of their students. Furthermore, the use of ICT is considered to favor the acquisition of skills in the area of music [12,15]. The combination with technological resources favors a progressive construction of the knowledge of music. At the same time, music education promotes sensitivity and enjoyment [16].

With technology and music together, symbiosis with other subjects, such as mathematics, can even be produced. Mathematical ideas, narrative nature of the lyrics, as well as the digital structure of the songs created collectively are brought together. At the same time, aspects of thinking-with-music-software related to musical concepts such as intervals, note values, and harmonic fields are put in relation. [17,18].

Music teachers must have digital skills that allow them to use everything that ICT offers, such as multimedia content [19,20] recorded explanations in the form of video-tutorials [21], or assessment tests that allow students to review their knowledge, become aware of both what they have learned and the level of knowledge they have at any given time.

Likewise, the virtual classroom is an excellent resource, since it has the identification of the users and the possibility of setting dates for the delivery of works and tasks, which are collected in blogs or in shared desktop folders [22].

ICT have been part of university life since their introduction in the 1980s. In Latin America, technology and improved training have become fundamental needs. One seeks to achieve greater interaction between society, the productive sector and universities, and a quality education. Thus, one seeks to cover the needs of the community. The Technical University of Manabí (UTM), attentive to these challenges, is adopting new models of education. In this regard, its academic authorities have called for an improvement in the methodology. Teaching music will be a common subject for several degrees.

1.2. Software Tools to Teach Music

Music software could be a tool that helps musical practices. This perspective on education is nourished by the "ubiquitous music" trend [23]. This trend proposes participatory practices of music education that exploit the available technological infrastructure. On the other hand, it expands such values as musical versatility and flexibility, as well as mobility between various musical communities of practice [24]. It is a democratization

It translates music education as "garage band pedagogy" [25] or "Songwriting and Technology Class" [26]. These methods encompass various modes of digital artistry: in

face-to-face pedagogical situations, contexts of informal learning, and open networked learning environments as remix sites and musical online communities. This model allows students to experience transitions between their musical engagement and learning in and out of school.

The Sibelius software is an example. It is a program for editing music scores and a sequencer of musical data that, according to its user's manual, allows the user to write and listen to the musical creations being recorded at the same time, giving the opening by means of mechanisms or patterns used by the music educator.

Software such as Sibelius offers a way to link visual and auditory feedback and carry out performances easily, very important to experiencing reading music [26–28]. Music editor can be a very useful tool for students who present certain difficulties in deciphering the musical code. This type of software can be a versatile tool to enrich both the musical technological knowledge of students and the type of activities that could be performed thereafter [29].

As mentioned above, new tools impose a new pedagogical model. In this scenario, the teacher must be digitally competent in incorporating ICT into his or her teaching methodology.

2. Materials and Methods

The main question of the study was as follows: How is ICT used to transform music teaching in an Ecuadorian University? An action research (AR) approach.

An AR requires the identification of a problem, the construction of a reasonable plan of action, and critical reflection on what happened [30].

To understand the AR process [31] the process in music education is explained showing different AR projects (Table 1).

The action plan for music education should create the conditions to execute it, monitor, and control incidents and results, and have the capacity to make improvements. Critical reflection should process the information available about the action plan and its circumstances.

The research team was voluntary. University students constituted the group that participated in the investigation. They had experienced the teaching-learning process of music or, in some way, had a relationship with this learning. There was a public invitation to participate. Therefore, the population and the sample were intentional. It was made up of educators and students at UTM. This university is a medium-size center in Ecuador, with 10 faculties and an offer of 33 degrees. There are a thousand professors and about 35,000 students. Eighty people ($N = 80$) with different previous experiences in the processes of musical formation, pedagogical methodologies, and knowledge of technological tools joined the group. Teachers ($N = 12$) were interested in changing music education. Students from the university ($N = 68$) were learning music theory and music notation. Students had been in prior courses learning music with some directions from the teacher and a flute student book.

Teachers, who acted as co-researchers, numbered twelve, four who teach the subject of musical education, four from the Department of Arts at UTM, and four other pedagogues.

The other part of the exhibition was made up of the students who applied to participate. Students were volunteers. They studied a common subject for several degrees on music education.

They worked with the group of teachers on the approach and object of the study, as well as on the general methodology of the AR.

Table 1. Examples of action-research researches in music education. Based on Cain (2008) work.

	Plan	Action	Evaluation	Reflection & conclusions
Mackworth—Young (1990)	Pupil-centered approach to piano lessons.	3 were ‘teacher-directed’, 2 ‘pupil-directed’ and 4 ‘pupil-centered’. Lessons were audio- and video-taped. Pupils’ and parents’ views were sought via questionnaires.	Flanders Interaction Analysis. independent observers.	Pupil-directed lessons help the teacher understand psychological and emotional factors
Barrett (1994)	Compositional experience at Primary education	Series of compositional challenges. Observation by the teacher, and students’ reflective diaries.	Students gained a greater understanding of the learning processes inherent in the arts.	Factors that led to greater musical understanding.
Hookey (1994)	To explore how generalist classroom teachers teach music when supported by a specialist teacher.	Audio and video recordings of planning, teaching and ‘reflective conferences’.	Patterns in the process of teacher reflections	Collaborative research allowed the teachers to confront previously held assumptions.
Miller (1996)	Connections between my music education agenda and the curriculum.	Over a 2-year period, weekly, 25-min, music lessons for first-grade children were collaboratively planned and evaluated.	Model of curricular integration.	Integrating music is not a single entity; it can involve associating music with topics from other areas of the curriculum.
Howard & Martin (1997)	To develop young composers.	Evolved from a symphonic band to group composing and composing for a professional piano duo.	A case study approach.	Group work can be ‘highly beneficial in the early stages of learning composition’.
Bannan (2004)	Pedagogical tool for harmony and student confidence to explore music through vocal improvisation	12 groups of singers. Data collection included observation, video analysis, and discussion with participants.	Data analysis methods are not stated but 5 examples of musical development are listed.	Harmony singing can have a valuable role in the development of musicianship.
Gaunt (2007)	‘To explore a range of approaches to teaching and learning breathing in oboe playing	11 oboe students at a conservatoire, over an 11-week period. Teaching included individual lessons, a seminar on breathing, Alexander Technique classes and workshops, focused on breathing. Data collection included video recordings, interviews, a questionnaire, the teacher’s reflective notes, and observations by a critical friend.	They made stronger connections between breathing and music, and developed strategies for reducing anxiety and self-criticism, but did not integrate physiological understanding with practical knowledge.	Key principles were shown to contribute to practice to different degrees.

The nominal group technique [32] was used for the collection and participatory analysis of information on the quality, relevance, and effectiveness of music education in universities. The nominal group technique facilitates the structured analysis of problems. Each participant reflects individually on situations, records his or her points of view and then reaches a consensus with the rest of the group. After identifying the situation or problem, as well as its elements, critical evaluations and individual ideas about what has been reviewed are developed in silence. Each collaborator writes down his or her impressions on the topic discussed as a result of his individual reflection. Then, in a meeting with his team, each of his ideas and comments are openly explained. The information is recorded. Subsequently, the wording is adjusted to establish if there are repeated ideas, so that it can be explained in a different way to those who did not understand it initially. Then the ideas recorded are discussed, and some are eliminated, redefining, relocating, grouping, decomposing, and writing the rest of the ideas. Subsequently, a silent individual activity is carried out, involving the selection of the available ideas, according to the importance credited. A 30-min break is then taken to rest and reinvigorate the group, and then reopen the process of analysis and debate. With the resumption of the reflective discussion of the results obtained, possible inconsistencies and a conclusive selection are established. It concludes with the list of agreements.

This technique made it possible to construct the questionnaire and the interview. The dimensions emerged related to the barriers for improving music education, for the attitudinal improvement of teachers, and the pedagogical difficulties of teachers.

For example, teachers identified problems in developing the class by observing phases such as motivating students according to their needs, clear presentation of information, use of examples, carrying out activities to reinforce concepts, and an evaluation that responded to the topics and activities developed in the class, which were grouped as “pedagogical difficulties”.

At the same time, a review of specific literature on new methodologies was carried out, the results of which were shared with the co-researchers.

Academic authorities were also interviewed about the type of university teaching they were looking for. The interview with authorities included questions about methodological change in higher education in Ecuador.

Armed with all of this, teaching was planned using a holistic and technological model of music education (HTMME). The model incorporates specific software for music (Sibelius). Popular melodies were offered to be analyzed with this software, accompanied by a variety of resources and activities with ICT. These resources were videos of popular music (related to popular melodies), as well as activities (i.e., to change tempo) and formative evaluation (questions about concepts developed in activities) in a platform of e-learning.

Work was carried out between January 2017 and September 2018. Up to 10 cycles or phases were planned, but only 5 could be developed.

Phases were:

- Phase I. First exposure of the project to the authorities. Definition of the team participating in the AR. Design and application of the pre-questionnaire to characterize and understand the problem. Review of the results of the questionnaire. Workshops to analyze the responses to the questionnaire. Reflection sessions on the opportunities for improvement identified in the questionnaire.
- Phase II. HTMME design meetings. Second presentation to the authorities and request for authorization of use. Execution Phase.
- Phase III. Application of HTMME. Application of the post-questionnaire. Evaluation of results of the questionnaire. Feedback Phase.
- Phase IV. Feedback to incorporate improvements. Improvement plan in support of the HTMME. Documentation and presentation of the research phase.
- Phase V. Report preparation. Presentation of the HTMME to the community.

The time to develop the research was consumed by a variety of difficulties in the implementation of it. At the end of each teaching period, data were collected through

unstructured interviews and questionnaires with teachers and students participating in the study. The model HTMME was successively improved with that information.

The questionnaire served to determine how teachers and students perceive the teaching of music. It was applied before (as a pre-questionnaire) and after the implementation of HTMME (as a post-questionnaire).

The dimensions it analyzed were the relevance of the improvement of music education, the barriers to that improvement, and the changes that can be implemented in the learning environment. It was intended to assess the attitudinal and pedagogical changes of teachers as barriers to improvement, as well as the improvement of their knowledge of advanced tools for teaching such as the Sibelius music software. Questions were related to the following: current methodology of music education at the Universidad Técnica de Manabí, main barriers for improvement, pedagogical difficulties in understanding, practicing and learning music classes, including practice activities, creation and editing of scores, benefits of the Sibelius program to improve the training of students attending music classes, the new music education model compared to the methodologies previously used, the main barriers and opportunities for improvement of the model, the main opportunities for methodological improvement, the main difficulties in understanding music classes.

The interview and questionnaire had been previously validated by experts. They reviewed the form and content and considered the relevance in relation to the objectives of the study. The specialists carried out a critical reading and made proposals for the correction of the questionnaire and the interviews.

A pilot test was also carried out with the questionnaire. The results achieved showed a Cronbach's Alpha of 0.85, obtained with SPSS v. 25, which is qualified as "very strong", with a reliability of 95% and a loss of precision of 3%, so the structure of the questionnaires was assumed to be valid and reliable [33]. As has been said, the analysis of the results was fundamental in generating improvements in the teaching model. Successive reports were discussed with the teachers. They integrated the data obtained with the questionnaires and the interviews.

In phase 1 of the study, thanks to the nominal group technique, the results of teaching practice around music at UTM were analyzed. Pedagogical experiences of music teaching catalogued as best practices were also analyzed. The possibility of using the Sibelius software was evaluated. In phase 2, design meetings were held with HTMME.

HTMME consists of:

- Masterly modeling by the teacher, with the complementation of other strategies.
- Motivating research, debate, argumentation and team work to improve the training process.
- Induction to the collaborative intervention of the teacher and student in the process of rationalization of information.
- An AR process with a team of teachers.
- Perennial generation and exchange of knowledge, skills, and social, institutional, and cultural experiences that support musical education.
- Dynamically analyzing the performance of teachers and students, based on software.

In phase 3, the application of HTMME and the questionnaire were produced. Following the evaluation of results, phase 4 was developed, providing feedback to incorporate improvements to HTMME. The team responsible for the study was not able to continue with more cycles or phases, which would have improved the model. The voluntary nature of the participants and their limitation in number and to one university also restricted the scope of the study.

3. Results

As stated in the methodology, nominal group technique and semi-structured interviews were applied before the model was tested. The participants in the study assessed various aspects through the questionnaire at the beginning and end of the implementation of HTMME.

They expressed, first and foremost, the need to improve musical training at UTM. The intention was to contribute to overcoming traditional educational practices.

This was not expected to be easy. Among the main barriers the following were identified, limitations or opportunities for improvement identified before the application of the model for the achievement of the competences provided by music education (Figure 1, Table 2), teacher attitude, didactics/pedagogy and technological support and, to a lesser extent, quality of hardware, class timetable, and infrastructure.

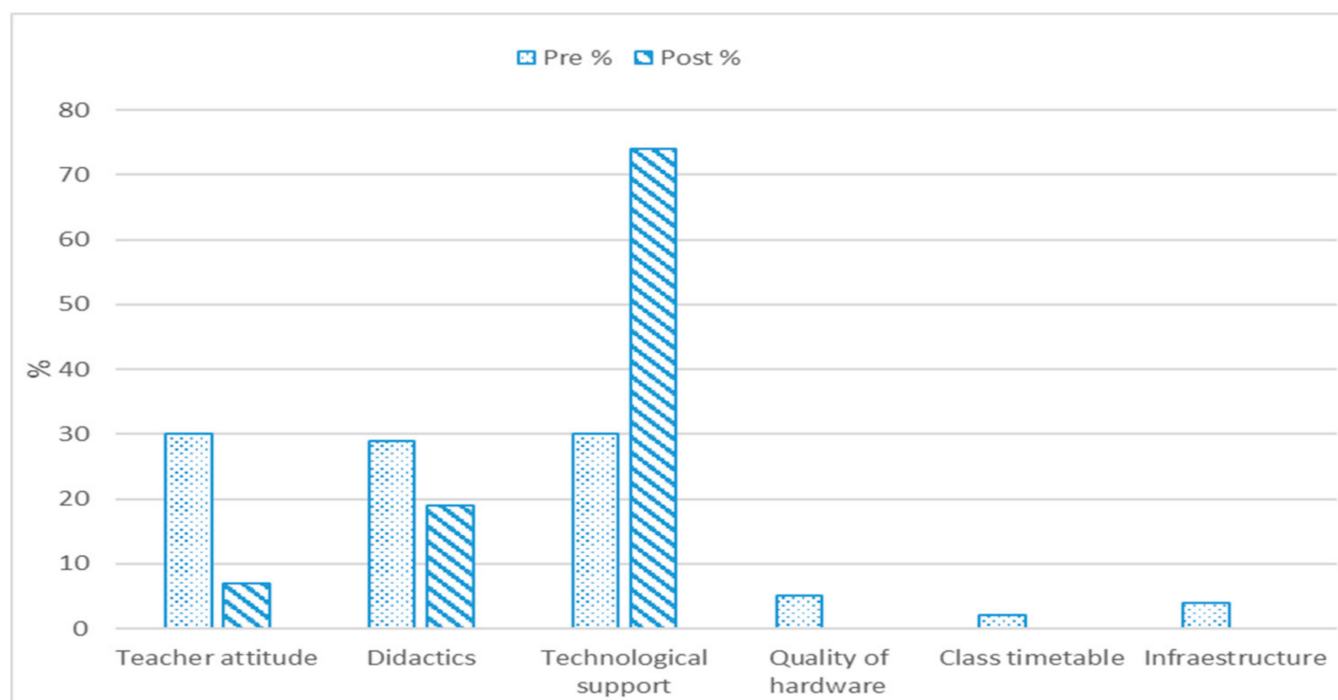


Figure 1. Barriers to improving music education.

Table 2. Barriers to improving music education.

Dimension	N Pre	Pre %	Post %
Teacher attitude	24	30	7
Didactics/Pedagogy	23	29	19
Technological support	24	30	74
Quality of hardware	4	5	0
Class timetable	2	2	0
Infrastructure	3	4	0
Total	80	100	100

With the implementation of the model, improvements were observed, although the problems derived from the handling of the Sibelius software introduced grew.

Regarding the attitudinal barriers (Figure 2, Table 3), demotivating attitude, thoughtless attitude, teacher-centered attitude, and bad rapport with students of the teachers were observed, limiting the collaborative participation of the students. These are a set of behaviors exhibited by teachers that refer both to traditional teaching and to a certain inability to connect with their students.

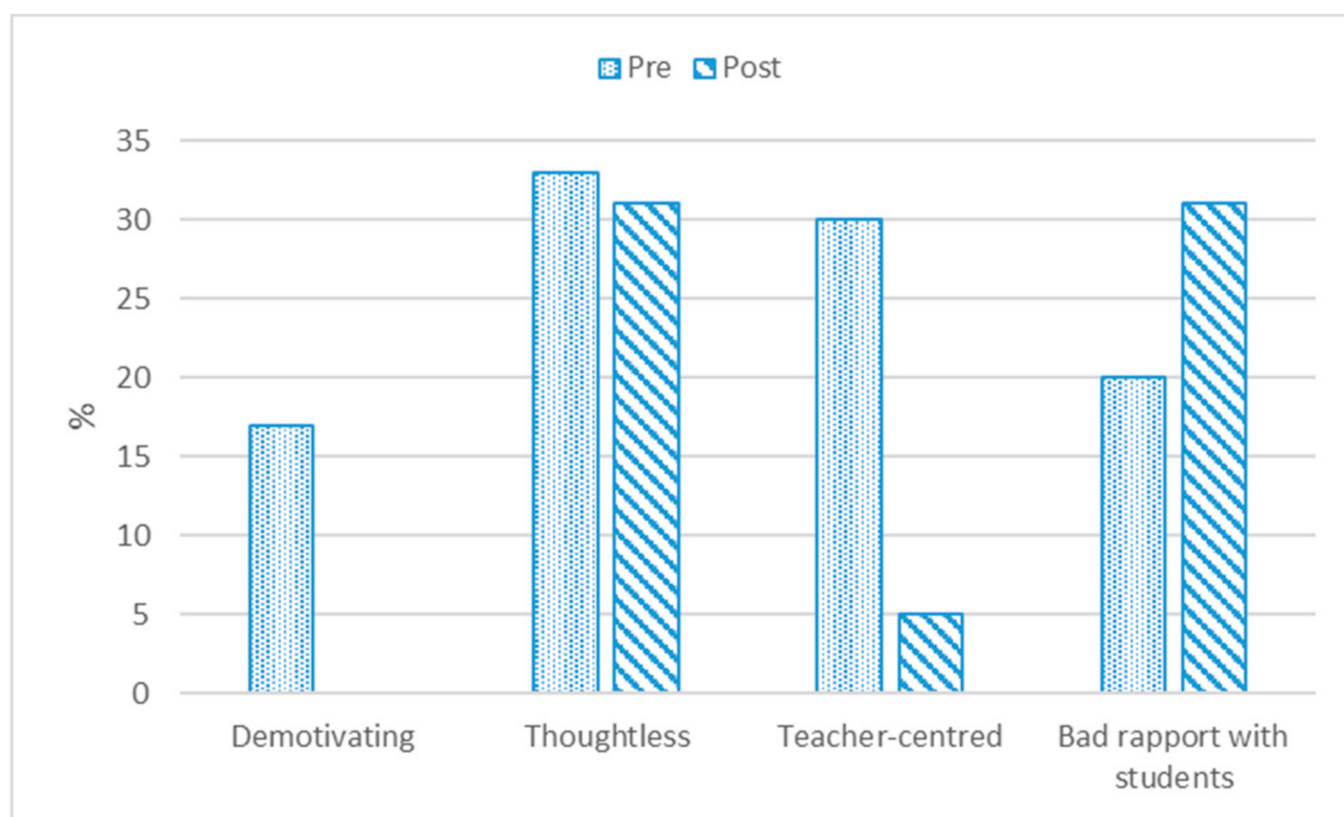


Figure 2. Barriers to attitudinal improvement in teachers.

Table 3. Barriers to attitudinal improvement in teachers.

Dimension	N Pre	Pre %	Post %
Demotivating	13	17	0
Thoughtless	27	33	47
Teacher-centered	24	30	6
Bad rapport with students	16	20	47
Total	80	100	100

With the implementation of the model, we observed a high level of student involvement in the classes, with the improvement of teaching, although some issues such as bad rapport with students were not resolved.

With respect to the pedagogical difficulties of teachers, the most important are ineffective evaluation processes and lack of improvement strategies. They are followed by lack of previous knowledge about the student, ineffective problem-solving methods, non-participatory knowledge generation, and lack of practical examples (Figure 3, Table 4).

Table 4. Pedagogical difficulties of teachers.

Dimension	N	%
Lack of previous knowledge about the student	14	18
Ineffective evaluation processes	20	25
Lack of improvement strategies	16	20
Ineffective problem-solving methods	11	14
Non-participatory knowledge generation	10	12
Lack of practical examples	9	11
Total	80	100

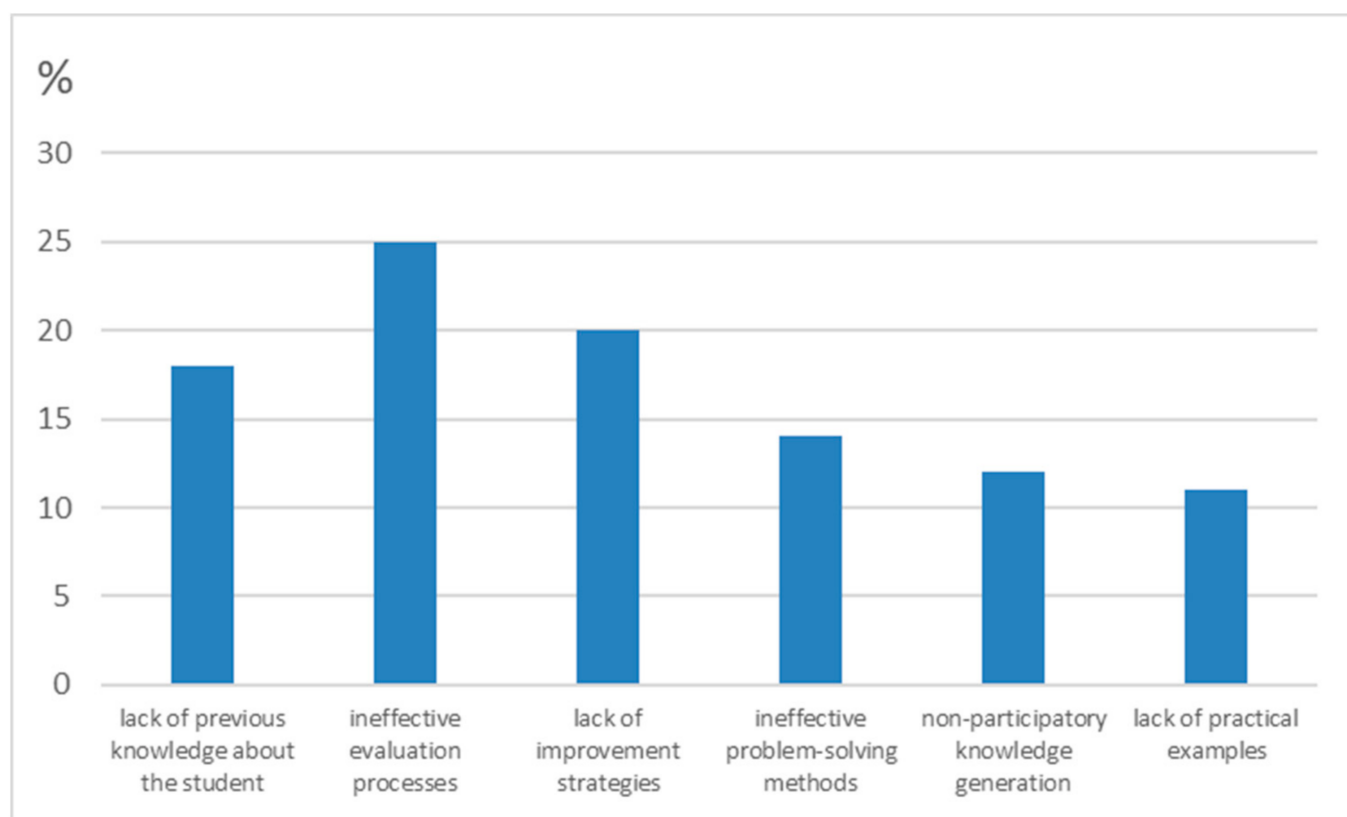


Figure 3. Pedagogical difficulties of teachers.

In the subsequent application of the questionnaire, a unanimous evaluation of the improvement of music teaching and advanced learning of the Sibelius tool was observed by 60% of the students.

As result of innovation experienced, the process of participant evaluation and discussion with co-researchers, the HTMME requires changes.

The AR process has the particularity that the knowledge about reality is not previous but is refined in the course of the phases. The nominal group techniques and the literature review made it possible to bring to light problems where it was advisable to improve the teaching of music to inexperienced students. The experience of a new model and its evaluation helped to consolidate ideas on key aspects. Attitudinal difficulties were transformed into recommendations for serving students in the classroom. Pedagogical difficulties became recommendations for developing the classes and technological difficulties became strategies for working with technology in the classes.

HTMME was organized in three dimensions: attitudinal, pedagogical, and technological. These dimensions were interdependent in transforming the method of teaching and learning music. With its application, it could be seen that the pedagogical problems were overcome.

Thanks to the interviews it was possible to specify for each dimension some important forecasts in the development of the model.

In the dimension of attitudinal management, the importance of emotional factors of the teachers in the formation of the students is recognized, such as a proactive and motivating attitude of the teacher. Emotional factors are possibly present as communication problems, as learning difficulties of musical language, and as technological problems involving a powerful software.

In the dimension of pedagogical management, variables such as the planning of the objectives pursued and their follow-up through pre-evaluation and evaluation of the students must be taken into account.

In the technological management dimension there appears the importance of pragmatic learning with technological support, the need to exploit all the technological features of the available hardware and software, and the usability of the tool.

After phase 4, from the evaluation of the results, some opportunities for improvement of the model appeared (Table 5) of technical, didactic/pedagogical, and attitudinal order.

Table 5. Holistic and technological model of music education (HTMME) improvement plan.

Opportunity for Improvement	Proposed Strategy	Focus	Time
78% assume greater mastery of Sibelius	Sibelius Training Program for teachers	Theoretical and practical training and support exercises	Annual
15% assume that teaching techniques must be improved	200-h course on best pedagogical practices	Poor motivational communication	Annual
7% propose to improve the teacher's attitude	Personal Growth Workshops	Emotional Intelligence, Self-Esteem, Active Listening	Quarterly

4. Discussion

The participants in the study expressed the need to improve musical training at UTM. This change is linked to the main purpose of the study, how is ICT used to transform music teaching in an Ecuadorian University? The intention was to contribute to overcoming traditional educational practices and stimulate creativity and participation of students, interacting in a visual, auditory, and practical way. It was presumed that by adopting a friendly technological tool it is possible to sensitize the university student and awaken interest in the musical arts.

ICT began with an AR project. Then, difficulties to improve linked to different problems were observed.

The main barriers to overcome traditional education are closely linked to the actions of the teacher, which he or she exhibits and manages.

With the implementation of the model, the handling of the Sibelius software introduced new problems. It seems that it is necessary for teachers to improve their mastery of it to help students.

The innovation does not resolve the bad rapport with students. New practices could imply a certain improvement in traditional teaching. There is still a certain inability to connect with students with the new methods.

With respect to the pedagogical difficulties of teachers, it is clear that teaching was perceived as being centered on content, regardless of other components of the pedagogical relationship, such as the students and the learning context.

After innovation it could be seen that the pedagogical problems were overcome. However, new problems related to the classroom climate arose, possibly due to difficulties in dealing with queries about software management by students. A certain lack of knowledge of some technical characteristics of the Sibelius software was also evident among the teachers, although the students acquired an acceptable mastery.

With interviews, it appears that the planning of the objectives pursued and their follow-up through pre-evaluation and evaluation of the students, must be taken into account. The AR forced the team of teachers to take an active contact with the groups of students, and this possibly was very important to adjust the model. The management of didactic/pedagogical resources [34], the impulse of autonomous learning, the resolution of problems in music education, the organization of spaces and the necessary hours of practice of the students, also becomes important, as several authors have also shown [35].

In the technological management dimension, issues already identified in studies on the initial training of music teachers, were highlighted as present in previous studies [35,36]. Innovation occurs thanks to a new look at a subject in the curriculum, as McPhail, Thorpe, and Wise report in the analysis of a New Zealand case [12].

It is possible that the low didactic/pedagogical and attitudinal demands are due to a “polluting” effect. It may be because of the effort made by teachers to work as a team to improve the model.

After the whole process of AR, it was observed that the HTMME project needs some actions to continue (Table 5). Some of them are linked to attitudinal dimension, as a way to overcome difficulties in this dimension. Workshops of teachers’ personal growth are needed.

On the other hand, the pedagogical dimension is required to improve the communicative processes in the classroom. A large course of best pedagogical practices needs to be implemented.

But perhaps the most complex problem is the implementation of teaching with technology. The use of Sibelius in the classrooms was perhaps the main problem detected by the participants. Teachers need to have a better command of it, as well as a kit of materials to work with students in the classroom. Theoretical training and monitoring of teachers are needed to help them to improve their classes with technology.

5. Conclusions

On the question of how is ICT used to transform music teaching in an Ecuadorian University, through AR in an Ecuadorian university, it arose that there is a robust model for doing so, the HTMME.

The interviews with authorities made it possible to become aware of the need for change in a subject being taught in a traditional manner. In the same way, it was a means to achieve institutional recognition of a process of change.

As the results of the questionnaire showed, Sibelius is very important in music teaching, but it is also important to take care of the attitudinal and pedagogical dimensions of the lessons.

This model allowed students with a certain interest in learning music to do so within a university subject. The initial difficulties in taking a music course seem to have been overcome. New difficulties certainly arose, as highlighted in the HTMME’s improvement plan at the end of the process. The mere introduction of technology in music education did not bring about change. It even generated new problems. Nominal group technique allowed teachers to perceive such difficulties collegially.

With the methodology put into practice, there was a renewed interest in music education on the part of the students. In the face of the difficulties they expressed prior to taking the subject, a certain general satisfaction could be observed in overcoming it.

On the other hand, it is clear that, in order to generate these changes, the model requires a key figure, which is a teacher or, rather, a teaching team with attitudinal, didactic/pedagogical, and technical competence. AR and co-researchers were very important in collegially understanding what was happening in the teaching model put in place. This model requires permanent work by a team of teachers. The dynamics of action-research helps to achieve this.

The AR possibly also contributed, indirectly, to improving the students’ confidence in the proposed way of learning music. Confidence in teachers and their attitude were increased and the teaching methods put into practice were found to be adequate, as the post-questionnaire showed.

With this model, new teaching experiences and relevant learning for students can be achieved. The study failed to discriminate whether learning music with ICT induces improved creative-musical processes in students. It was observed, however, that there was a high percentage of students who achieved advanced mastery of complex and fruitful

software for music practice. As in other cases, technology reinforced a process of change that was already underway.

In any case, it would be convenient to study in depth the viability of the model in successive phases or cycles. Unfortunately, the AR process could not be continued for longer.

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