2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #39212

Students' Perception of Active Learning in the Acoustic Physics Course

Johanna Antonia Perasso, Universidad Andres Bello, Chile
Prof. Angeles Dominguez, Tecnológico de Monterrey, Mexico; Universidad Andres Bello, Chile

Angeles Dominguez is a researcher at the Institute for the Future of Education, a Professor at the School of Humanities and Education, and the Associate Dean of Faculty Development at the School of Medicine and Health Sciences at Tecnologico de Monterrey, Mexico. Also, she is currently collaborating with the School of Engineering at the Universidad Andres Bello in Santiago, Chile. Angeles holds a bachelor's degree in Physics Engineering from Tecnologico de Monterrey and a doctoral degree in Mathematics Education from Syracuse University, NY. Dr. Dominguez is a member of the Researchers' National System in Mexico (SNI-2) and has been a visiting researcher at Syracuse University, UT-Austin, and Universidad Andres Bello. Her main research areas are interdisciplinary education, teaching methods, faculty development, and gender issues in STEM education. She actively participates in several national and international projects, in mathematics, engineering, and science education.

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Abstract

For several years now, university education has been moving towards implementing active learning methodologies in sciences, where the application of knowledge and student agency and participation are key components. This trend has taken on different nuances and colors depending on the educational level, disciplinary content, institutional culture, and educational structure, among other factors. Among these methodologies, we highlight the proposal by Sokoloff and Thornton, known as Interactive Lecture Demonstration (ILD), which allows for the transformation of a passive class into an active one, enabling students to be the protagonists of their learning.

The purpose of this study is to evaluate the impact of a modified version of the ILD on the teaching and learning of a physics course through the students' perception. The modified ILD has the same three stages as the original ILD, with two main differences in who performs the experiment and when it is performed. Specifically, the three phases in the modified ILD are 1) predict, 2) experiment (by students working in groups, not the instructor), and 3) reflect (in groups, not individually). The first phase, prediction, begins with the analysis of a physical situation in which students have to predict the behavior of the situation based on the knowledge imparted in the session by the instructor. This occurs at the end of the instructor's exposition. The second phase occurs in the laboratory section of the course and relates to students' experience in carrying out the experiment of the situation worked on in class. Finally, students, working in groups, carry out the experimentation and reflect on it at the end. This reflection occurs in their working groups. The modified ILD combines the theoretical class (mainly exposition by the instructor) with the experimental class to offer students an integrative experience. This study involved 47 students from two groups of a first-year university course in acoustical physics.

Applying the modified ILD methodology, a qualitative study was conducted analyzing the students' responses to the guides and their conclusions. This study presents the results of the analysis with a focus on determining the students' scientific skills in obtaining data and experimental analysis and evaluating their perception of the course in general. The conclusions delve into the advantages/disadvantages of applying this methodology in this course and a proposal for transferring this methodology to other physics courses.

Keywords: active learning, Interactive Lecture Demonstration, non-physics major students, educational innovation, higher education.

Introduction

The teaching of STEM at all educational levels is a continuously researched topic that has led to a improve and share good practices [1], due to the little success in terms of its learning [2], [3], and [4], whether due to intrinsic motivation [5] , [6] the difficulty that students have in connecting it with their current and future life [7], problems in understanding mathematics, lack of laboratories in schools, or simply due to the scarcity of physics teachers in secondary education [8].

In university education, teaching STEM areas implementing active learning strategies particularly in the teaching of active learning [9], [10], [11], [12] and [13] has open many opportunities and offer a variety of classroom dynamics and strategies that transform students' role from passive to active learners. Such is the case of implementing Interactive Learning Demonstrative methodologies (ILD) introduced by [14] and integrating the laboratory into physics classes [15] and [16].

The reasons for the lack of motivation [6] that primary and secondary students have in learning physics are difficulty in understanding what they are being asked to do [17], considering physics as distant from their reality, depersonalization in the teacher-student relationship, and the fact that they are only taught to solve theoretical exercises with excessive mathematical development [18]. All of this implies a scientific education that is disconnected from their daily life, where in some cases, they have only studied formulas that they must memorize to pass the course or have learned physics in a traditional way where the teacher or textbooks are the only sources of knowledge, laboratory work is used to confirm the theory, the teacher assumes responsibility for learning, and there is no room for collaborative work [9]. With all of this, students arrive at higher education with little motivation, with entrenched misconceptions that prevent them from progressing and succeeding in physics courses.

All of the above creates in the teacher the need for a search for modification and creation of new active methodologies for science education [11]. Studies on science education demonstrate that active teaching methodologies, particularly experimental activities, are highlighted in the teaching of physics, as they promote scientific reasoning and critical thinking [16]. Active primary, secondary, and university science education has increased students' academic performance. Meltzer and Thornton [10] have conducted research over the past 25 years that supports the effectiveness of these methodologies in students' performance, and retention of the content learned over time.

Among the active methodologies, we highlight the proposal called Interactive Lecture Demonstration (ILD) [14], which allows for changing a traditional passive class to an active one. This practice aims to achieve conceptual learning through the performance of an activity where students individually predict a physical phenomenon through the visualization of an experiment performed by the teacher and then discuss and conclude as a group.

Despite the success of this methodology, several modifications have been necessary, mainly to adapt it to different educational contexts. The following are some modifications made to the ILD methodology, which have been evidenced in the literature.

Ramírez proposed a modified 4MAT learning cycle that combines 4MAT [4], which considers four learning styles based on David Kolb's proposal and the eight steps of Solokoff's ILD. Ramírez in [15] adapted the ILD for distance teacher training, allowing them to replicate this adaptation with their students.

López and Orozco proposed conducting the ILD with PHET simulations, following the same eight steps [16]. Still, the experience shown would no longer be in concrete form with equipment but rather with a computer and a simulation. The justification for changing experiments to simulations is due to the scarcity of materials, infrastructure, and high costs.

The author of this methodology has also replaced practical experiments with Phet and Fislet simulations, called "ILDs adapted to the home," on their website, emphasizing the importance of predictions and discussions with peers before viewing the simulations.

The following research focuses on the perception of students facing a physics course for the first time, implemented with an active methodology based on Sokoloff and Thorthon methodology called Interactive Lecture Demonstration [14], which has been modified. Despite the modifications made to this methodology, which can be found in the literature, there are few reports on students' perceptions of these modifications. Therefore, we aim to answer the following question: What is the perception of non-physics major students regarding the modified ILD?

Didactic methodology

The didactic methodology used in this study is the Interactive Lecture Demonstration (ILD) by Sokoloff [14], which has been modified to improve student learning outcomes. This study aims to measure the perception of students learning with this modified ILD methodology and determine if this approach to teaching and learning is relevant to their future profession.

The ILD methodology was implemented with 61 students studying speech therapy at two private university campuses, with 51 female and three male students. Before implementing the ILD methodology, Figure 1 shows the design process to transform a curriculum taught in a traditional way to a one using active learning strategies, specifically, ILD.

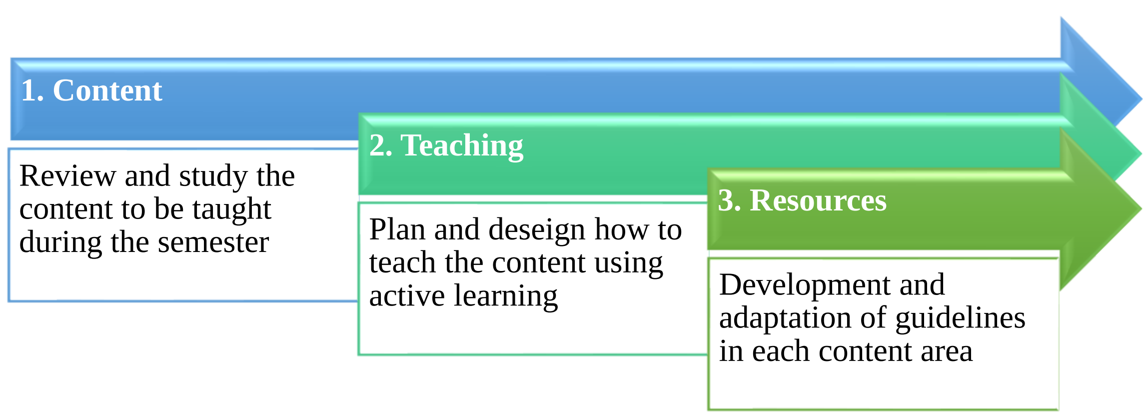

Figure 1. Stages of the design process of the course to adapt it to an active learning course.

In the first stage, the instructor reviews the structure, sequence, and contents of the course to analyze the topics in which the Modified ILD could be implemented covering the learning objectives. In the second stage the planning and designing of the course transforms the lesson plans by incorporating an active methodology adapting the time spent in each topic. This planning of the course implementation considers an organization of contents and implementation of the methodology that allows students to familiarize with the teaching methodology while they improve their competences, such as, collaborative work, group discussion, argumentation, reflection, among others. In the last step, the developing of the guidelines focusing on main concept ideas and adapting the methodology considering resources, time allocated for the topic, students background, and objectives.

Modified ILD

The implementation of the teaching strategy consisted of a sequence of experimental workshops that the students carried out following the guidelines designed in stage 3 of the above process. The active learning methodology was a modification of the Interactive Learning Demonstration (ILD) developed by Sokoloff [14]. This Modified ILD is designed to bridge the gap between theoretical classroom hours and hands-on experimental workshop hours. In experimental workshops, students acquire basic scientific concepts through experiential learning. In the ILD methodology [14], students follow a sequence of Predict, Observe, and Conclude (POC) in one session or class. In the Modified ILD, the sequence is Predict, Experiment, and Conclude (PEC) and is conducted over two sessions (Figure 2).

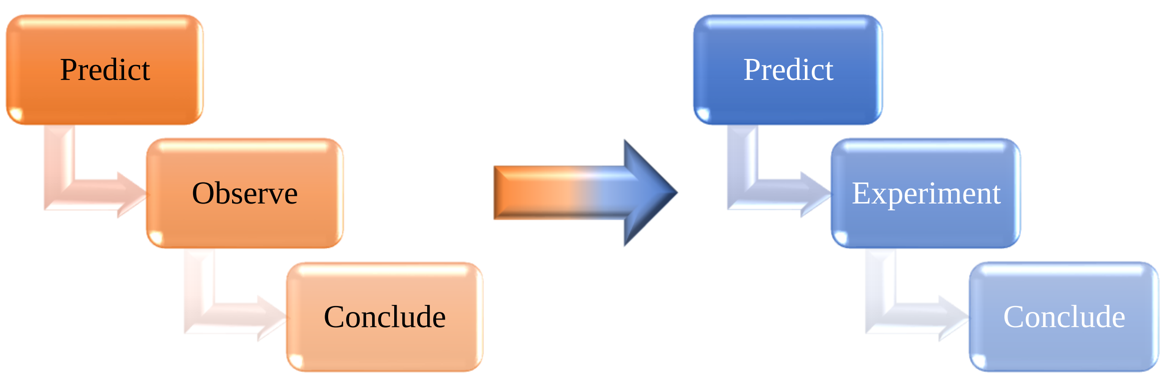

Figure 2. Students learning sequence of the ILD (in orange) and its transformation into the Modified ILD learning sequence (in blue).

The first part of the PEC guide, the prediction, is delivered in the first session. While the second and third parts, the experimentation and the conclusion, occur in the second session. Table 1 compares the five steps of the ILD [14] to the five steps of the Modified ILD. In the latter, students conduct experimentation (active role) instead of observing (passive role).

Table 1.
Description on each step of the Sokoloff's ILD process [14] compared to the Modified ILD process.

ILD [14]	Modified ILD
- The teacher describes and performs the demonstration for the class without taking data.	- At the end of the class, the teacher provides a guide that presents a situation related to the content taught in class.
- The students are asked to record their predictions on a prediction sheet, which will be collected and can be identified by each student's name written at the top. (Students are assured that these predictions will not be graded, although some credit is typically given for attendance and participation in these ILDs.)	- Each student writes a prediction on their sheet, submits it at the end of the class, and identifies with their name. (Students are assured that these predictions will not be graded, although they are a passport to carry out the experimental activity).
- The students engage in discussions in small groups with one or two of their peers.	- N/A
- The instructor gathers common predictions from the students across the entire class.	- N/A
- The students record their predictions on the prediction sheet.	- NA
- The instructor performs the demonstration with measurements (usually graphs collected with laboratory tools based on microcomputers) displayed on a suitable screen (various monitors, LCD, or computer projector).	- The students perform the experimental activity in groups.
- Some students describe the results and discuss them in the context of the demonstration.	- Students may complete a results sheet identical to the prediction sheet, which they can take for further study. Students describe the results on an experimental activity sheet, which they complete with their results.
- The students (or the instructor) discuss physical situations analogous to the one presented in the experiment but with different surface characteristics (i.e., different physical situations based on the same concepts).	- The students in groups describe and discuss their results with the predictions made in the previous class and draw conclusions.

Note: The Modified ILD used in our project consists of 5 steps and introduces the PEC guides (Predict, Experiment, Conclude).

The PEC guides are important for the Modified ILD methodology because they promote individual work and as a team. In this way, students confront alternative conceptions at the beginning and end of the activity, both alone and collaboratively. They conduct the experimental activity following the guidelines (active role of the students) under the teacher's supervision (instructor as facilitator). The guidelines foster students' collaboration, promoting argumentation, discussing and sharing ideas to define the best way to carry out the experiment. Students are connecting their ideas, shaping and re-shaping their conceptions as the course progresses.

Methodology

This is a cross sectional quantitative study with a non-experimental research design. The data collection consisted of a survey implemented at the end of the semester (Figure 3). The implementation of the Modified ILD took place throughout the duration of the semester (week 1 to week 14). During the last week of classes and before the final exam, we implemented a survey to gather students' perception about instructional practice.

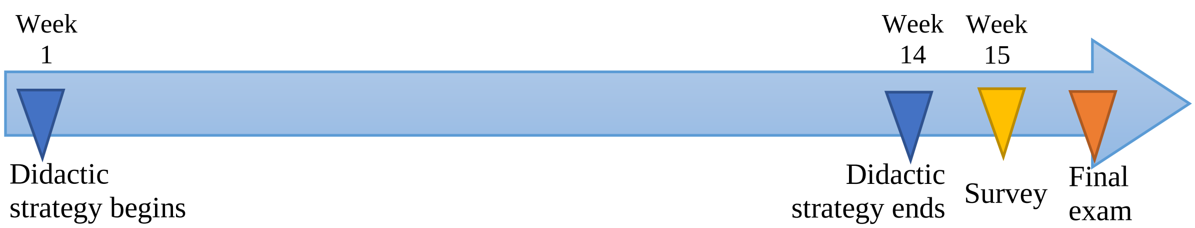

Figure 3. The blue arrow represents the semester in which the didactic implementation took place. The blue triangles indicate the beginning and the end of the active learning methodology (Modified ILD) and the yellow triangle marks the data collection that occurred with the adapted StRIP survey.

Participants

At the end of the semester, a survey was conducted to first-year university students taking the Acoustic Physics course in the Speech Therapy program in the Rehabilitation Sciences from a university in Latin America. The purpose of the survey was to understand their perceptions of the active learning methodologies implemented throughout the semester.

There were 61 students enrolled in two groups of the Acoustic Physics course. Group 1 had 26 students and the second group had 35. In total, 52 students responded to the survey implemented in person, 23 form group 1 and 29 from group 2, about 85% of responses. Given the group size and the purpose of this paper, we will not direct our analysis per group.

A particular characteristic of the participants is that in the 61 students enrolled in the course, only three were man, and two of them out of the 52 who responded the survey. That is, this is a predominantly course for women. This may relate to a situation that occurs even before the students enter the university, meaning the determining factors and actors that influence young women in deciding whether or not to study a STEM career [19] and [20].

Instrument

The survey was taken from [21] Quezada, Dominguez & Zavala (2020), a validated Spanish version of the original work by [22] DeMonbrun et al. (2017) on the design and validation of an instrument to measure student response to instructional practices, better known by the acronym StRIP. Table 2 indicates the dimensions of the instrument validated Spanish version adapted and included in the survey for the acoustic physic course.

The StRIP uses a 5-point type of Likert scale for dimensions 3 and 4. Specifically, response options for each item of these dimesions are: 1 = almost never (<10% of the time); 2 = seldom (~ 30% of the time); 3 = sometimes (~ 50% of the time); 4 = often (~ 70% of the time); 5 = very often (>90% of the time).

Table 1.

Dimension, description, factors, and number of items of the StRIP instrument [22] that correspond to the same items implemented in its Spanish version [21].

Dimension	Description	Factor	Number of items
1	Student Responses to Instruction	Value	3
1	Student Responses to Instruction	Positivity	3
1	Student Responses to Instruction	Participation	6
1	Student Responses to Instruction	Distraction	5
2	Using In-Class Activities Items	Explain	4
2	Using In-Class Activities Items	Facilitate	4
3	Types of Instruction	Active	6
3	Types of Instruction	Passive	3
3	Types of Instruction	Interactive	6
3	Types of Instruction	Constructive	6

Note: The colors on the factors of dimension 3 (Type of instruction) are going to be used throughout the rest of the paper.

The items of dimension 3 are the same as for dimension 4. The difference is the perspective. While the third dimension focuses on the actual class, the fourth dimension focuses on the ideal class. That is, students respond to the type of instruction that they experienced in their acoustic physics course, and then they respond to the same items on how they perceive the ideal type of instruction for that course. For this paper we are going to focus our analysis on the students' perception about the actual type of instruction implemented and their ideal instruction for that course. At the end of the paper, in the Appendix section, we have included the list of items for dimensions 3 and 4. We use the same color code to ease factor identification.

Results

This paper focuses on the responses to the StRIP survey in its Spanish version [21]. Particularly, to the items of dimensions three and four, same items with a different perspective. Dimension 3 focuses on the actual type of instruction that occurred in the course (from the perspective of the student), whereas dimension 4 asks the same questions but on the ideal course (students' perspective).

For the analysis, we are only discussing items in which we found a significant difference between them when a t-test was applied between the corresponding items of dimension 3 and dimension 4. For instance, for the factor of interaction, we compare response 3d with 4d, 3g with 4g, and so on. A significant difference indicates what aspects students would like for the type of instruction to change. This applies to all the items of each factor in each of the dimensions (see Appendix for the list of items).

To analyze the result, we are regrouping the responses from a 5-point to a 3-point scale. On one end we added up responses of 1 = almost never (<10% of the time) and 2 = seldom (~ 30% of the time) to represent the less frequent. On the other, we added up responses of 4 = often (~ 70% of the time) and 5 = very often (>90% of the time) to represent more frequently occurring in the actual or in the ideal course for that particular action of each item. The following are the results obtained through the questionnaire.

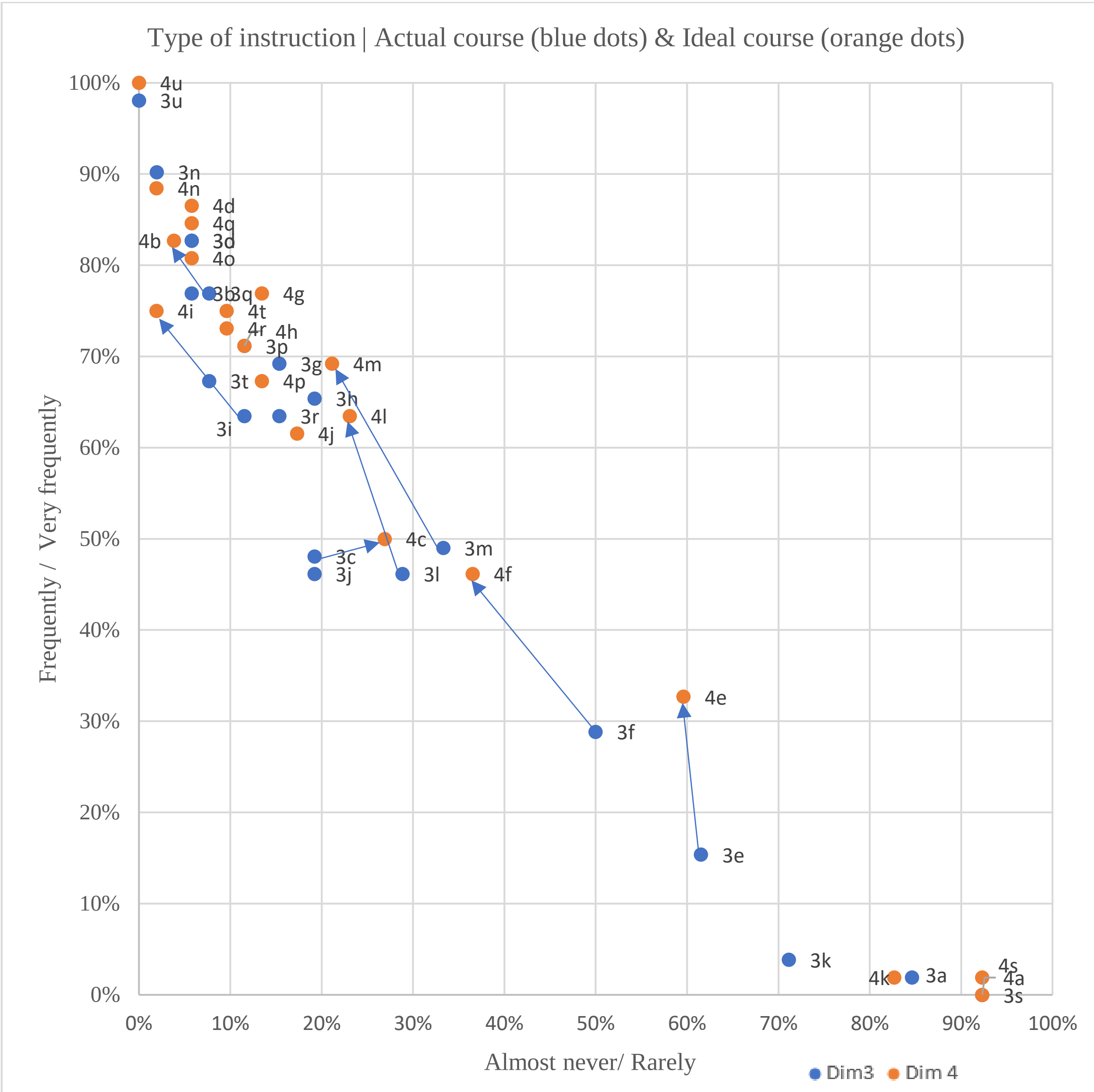

Figure 1. Students' perception of the actual class versus students' ideal class description. Graph showing the percentage level of acceptance, frequently and very frequently (4 and 5) versus rarely and almost never (1 and 2). The current classes are represented by blue dots, and the future or ideal class by orange dots.

In general, the graph shows the percentage of agreement by students regarding the Active Methodology with Modified ILD implemented in contrast to their expectations of a future or ideal class.

From Figure 1, we can see that their classes had the characteristics of an Active Methodology, and they would also like their future classes to have those characteristics. This is evident as the orange points representing the ideal active classes have a higher percentage of approval than the actual active classes with Modified ILD represented by blue points.

Next, we will show some graphs with questions that have a significant difference.

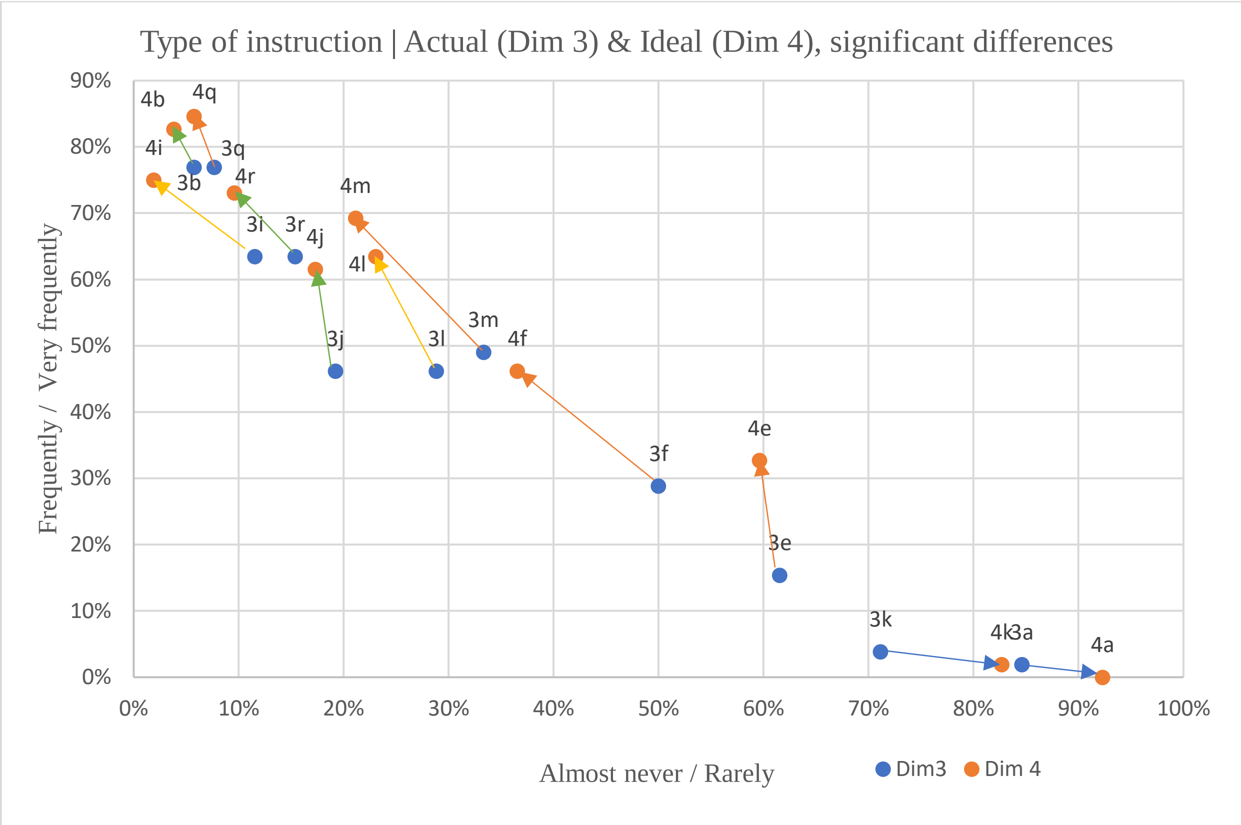

Figure 2. Level of perception of an ideal course and the actual course only for those items with a significant difference. The color of the arrows corresponds to each factor, active in orange, passive in blue, interactive in yellow, and constructive in green.

Figure 2 displays on the horizontal axis the percentage of students who rated the questions (i,r,j, etc.) with 1 and 2 (rarely and almost never) versus the percentage of students who marked 4 and 5 (frequently and very frequently) for the current class and the ideal or future class. The questions are associated with the type of instruction, as indicated in Table 2, such as active (orang arrows), passive (blue arrows), interactive (yellow arrows), and constructive (green arrows). The arrow indicates the shift in perception from the type of instruction that students perceived in their actual course to their ideal type of instruction. Notice that all arrows of items with significant difference point up for three of the factors (active, interactive, and constructive), meaning that students would like more of that action in their ideal type of instruction. Whereas for the passive factor, we observe that students are reluctant to abandon the type of instructions that requires a passive role from them [23]. This is discussed further in Figure 4 at the end of this section.

Table 2

Questions associated with type of instruction.

Description	Factor	Item	Items with significant difference
Type of instruction	Active	e, f, m, o, p, q	e, f, m, q
Type of instruction	Passive	a, k, s	a, k
Type of instruction	Interactive	d, g, i, l, n, u	i, l
Type of instruction	Constructive	b, c, h, j, r, t	b, j, r

For the actual course, Figure 2 shows the percentage in which, from the students' perspective, the instructor performed or asked them to do certain actions in class, such as discussing concepts with classmates and solving problems in groups, among others. For the ideal course, students indicate the percentage in which they would like the actions to occur as part of the type of instruction. This is particularly important, since a semester has (on average) 30 session (15 weeks) counting lectures and workshops, and the entire actual course implemented an active learning methodology, and students perceive that they would like more of that type of instruction. In figure 3 and Figure 4, we graph two factors in each, interactive and constructive type of instruction (Figure 3), and active and passive in Figure 4.

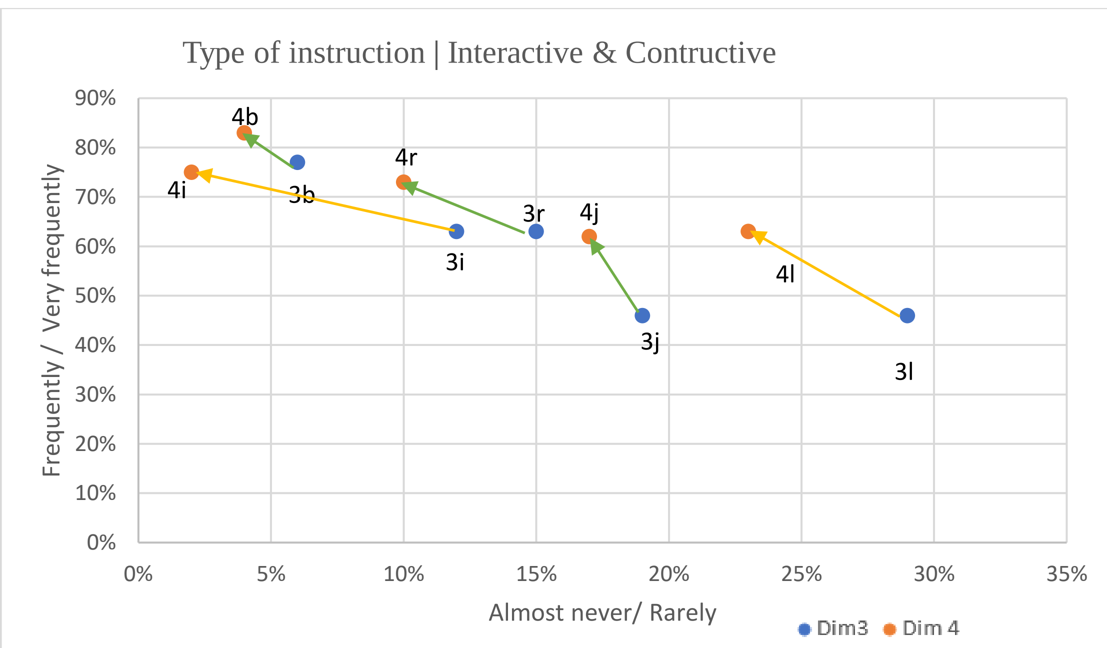

Figure 3. Percentage of perception of the actual course (blue dots) and the ideal course (orange dots), for items with a significant difference for the interactive and the constructive factors. The color of the arrows corresponds to each factor items, interactive in yellow, and constructive in green.

According to Figure 3, it seems to show a trend for the characteristics of a constructive and interactive type of instruction by looking at the shift from the actual course (blue dots) to the ideal course (orange dots). Specifically, responses within the constructive factor associate with thinking of different solutions to a problem (b), taking initiatives (r), justifying assumptions when not all the information is available (j); and those from the interactive factor about discussing concepts with classmates (i), and being graded based on my group (l) have a tendency for students to want their ideal course to have more often these qualities of an active methodology.

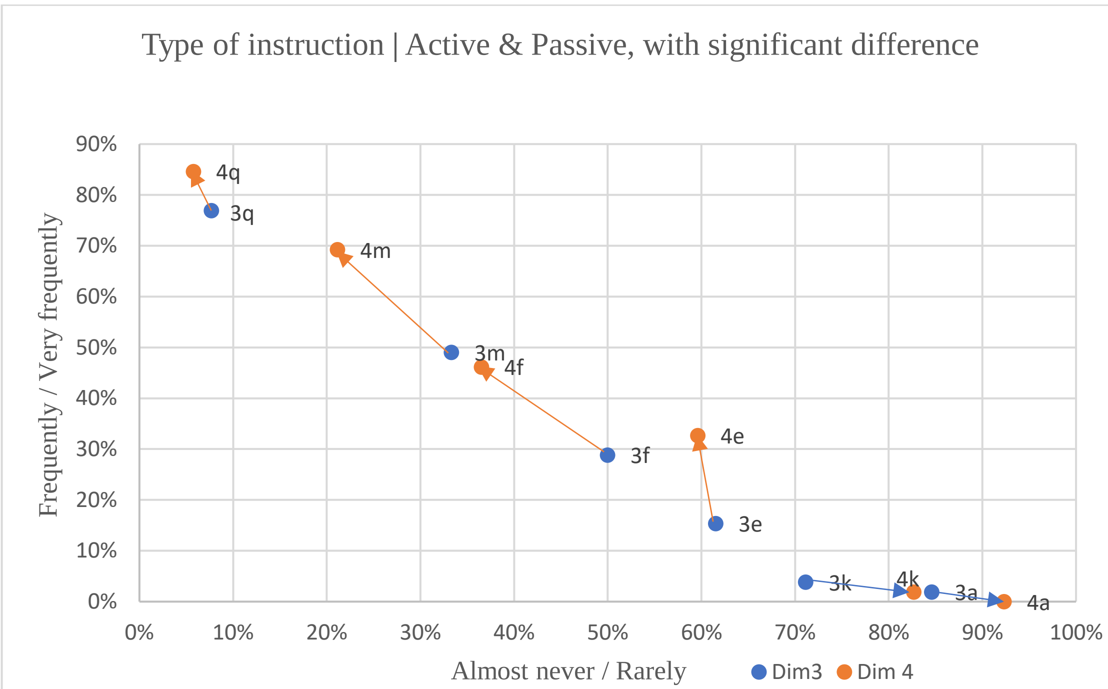

Figure 4. Percentage of perception of the actual course (blue dots) and the ideal course (orange dots), for items with a significant difference for the active and passive type of instruction. The color of the arrows corresponds to each factor item, active in orange, and passive in blue.

In Figure 4, we have the items that resulted with significant difference for the two other factors of types of instruction, active and passive. The characteristics representing an active type of instruction show their shifts from the actual to the ideal course with orange arrows (Figure 4). These items refer to making individual presentations to the class (3e and 4e), being graded for class participations (3f and 4f), previewing concepts before class by reading, watching videos, etc. (3m and 4m) and ask the instructor questions during class (3q and 4q). As indicated in Table 2, the factor active type of instruction has six items, and four of them (e, f, m, and q) resulted with significant difference with shift from the actual course instruction (dimension 3) to de ideal type of instruction (dimension 4) in the direction that would indicate more percentage of students are in favor and willing to experience more of that active role. These characteristics show an increase in the percentage of students' responsibility and participation in their ideal course.

In the lower right corner of Figure 4, we find the two (out of three) items of passive type of instruction that resulted with significant difference. Item "a" read as *Listen to the instructor lecture during class* and item "k" as *Get most of the information needed to solve the homework directly from the instructor*. Both items portray a passive role for the students, thus we analyzed them as negative items. Since the arrows point in the right and down, it is interpreted as the student having difficulty to abandon their teaching-learning paradigm that they are most used to and feel confident and familiar, meaning a more prominent active role from the instructor and a more passive role for the students [23]. We consider that even though for the other dimensions (active, interactive, and constructive) about half of the items resulted with significant difference, students struggle to take full responsibility. We see this as part of the transition from a passive to an active learner role and believe that if more courses are taught in a way to empower students about their learning, they will gain the confidence and take the responsibility needed.

Conclusion

The research question of this study is What is the perception of non-physics major students regarding the modified ILD? Participants were first-year students enrolled in the only physics course of their academic program. A specific question arose when we notice that the composition of the classroom had mainly women (95% approximately), from that, 3.8% of the respondents were man (only two out of three).

Regarding the main question, in general students' perception of the Modified ILD active methodology is considered good, as they express through their responses seen in all the previously presented graphs (Figure 1, Figure, 3 and Figure 2). That is, in Figure 1 we notice a tendency for most of the shifts from actual course type of instruction (blue dots) to ideal type of instruction (orange dots) meaning students willingness to take a more active role in the physics course. This result compares to [24] in which they found that students not in a physics related program achieve good results showing a positive perception about the physics demonstrations implemented in that study.

At the beginning of this research, we thought that students had a favorable tendency towards traditional classes and that their preference for an active class would decrease since it involved the teacher being the leader and protagonist of the teaching and students being only recipients of content to define later what to study and how to do it, which involved less effort on the part of students in the class. This could be perceived because some students at the beginning of the semester made comments related to wanting the teacher to explain the content on the board or not wanting to work in groups, which we can explain as them not being used to or not knowing this type of methodology. Also, we were considering that most often, instructors know what content is essential for students' learning, but that not always matches what students believe is important for their learning [19] [25], or for the type if instruction that best suits the content [10],[16] and[17].

Through the surveys, we believe that the Modified ILD allowed students to learn to work collaboratively in groups, acquire concepts through experiments developed in a group manner, and analyze, discuss, and obtain conclusions. This was pleasant and beneficial for their personal learning and successful acquisition of the expected learning outcomes in their course on acoustical physics.

Regarding the gender perspective, we conclude that the implementation of the active learning methodology had a positive impact on the students (majority women), and that this comes to exemplified some of the results that indicate that active learning methodologies democratize the classroom and opens to diversity by giving voice to all [26], [27].

Therefore, we can conclude that the students' perception was positive towards the type of instruction. This motivates us to continue working on it for the benefit and support of physics education, which is essential for the formation of new generations of students.

Recommendations

To implement the Modified ILD, all five steps should be followed entirely as they are closely related to each other. The workshops are as important as the lectures. The laboratory workshops should be aligned with the lectures and focus on an important and fundamental abstract concept for learning that will serve as a scaffold for future, more complex concepts.

A classroom that enables and facilitates teamwork is essential.

Next steps

To verify whether there is improvement in the standardized test results for the concepts taught in the courses offered by the Department of Physical Sciences.

We would like to explore the possibility of implementing this methodology with experiments associated with PHET and the use of a software tracker, which would enable the expansion of this methodology to institutions that do not have the necessary resources to implement an experimental workshop.

Acknowledgments

The authors recognize and appreciate the support and enthusiasm given by all laboratory course instructors in implementing innovative didactic strategies and to all students for their valuable engagement in their learning.

The authors would like to acknowledge the leadership and financial support of the School of Engineering of Universidad Andres Bello, Chile. We also express our gratitude to the

Educational and Academic Innovation Unit (UNIDA) for mentoring and guidance in developing scientific articles in higher education research.

In addition, the authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this work.

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Appendix

Items corresponding to dimensions 3 and 4 colored by factors.

Active
Passive
Interactive
Constructive

Note: The actual survey format appeared in numerical order without color.

	Indicate the frequency with which you carried out the following activities during this course. Taking into account that, on average, this course has 30 sessions during the semester counting lectures and workshop.	1. Almost never (<10% of the time) 2. Rarely (~30% of the time) 3. Sometimes (~50% of the time) 4. Frequently (~70% of the time) 5. Very frequently (>90% of the time)				
#	Item					
3e	Make individual presentations to the class	1	2	3	4	5
3f	Be graded on my class participation	1	2	3	4	5
3o	Solve problems individually during class	1	2	3	4	5
3p	Answer questions posed by the instructor during class	1	2	3	4	5
3q	Ask the instructor questions during class	1	2	3	4	5
3m	Preview concepts before class by reading, watching videos, etc.	1	2	3	4	5
3a	Listen to the instructor lecture during class	1	2	3	4	5
3s	Watch the instructor demonstrate how to solve problems	1	2	3	4	5
3k	Get most of the information needed to solve the homework directly from the instructor	1	2	3	4	5
3n	Solve problems in a group during class	1	2	3	4	5
3u	Do hands-on group activities during class	1	2	3	4	5
3i	Discuss concepts with classmates during class	1	2	3	4	5
3d	Work in assigned groups to complete homework or other projects	1	2	3	4	5
3l	Be graded based on the performance of my group	1	2	3	4	5
3g	Study course content with classmates outside of class	1	2	3	4	5
3j	Make and justify assumptions when not enough information is provided	1	2	3	4	5
3c	Find additional information not provided by the instructor to complete assignments	1	2	3	4	5
3r	Take initiative for identifying what I need to know	1	2	3	4	5
3b	Brainstorm different possible solutions to a given problem	1	2	3	4	5
3h	Assume responsibility for learning material on my own	1	2	3	4	5
3t	Solve problems that have more than one correct answer	1	2	3	4	5

	Indicate the frequency with which you would like the following activities to occur during this course. Taking into account that, on average, this course has 30 sessions during the semester counting lectures and workshop.	1. Almost never (<10% of the time) 2. Rarely (~30% of the time) 3. Sometimes (~50% of the time) 4. Frequently (~70% of the time) 5. Very frequently (>90% of the time)				
#	Item					
4e	Make individual presentations to the class	1	2	3	4	5
4f	Be graded on my class participation	1	2	3	4	5
4o	Solve problems individually during class	1	2	3	4	5
4p	Answer questions posed by the instructor during class	1	2	3	4	5
4q	Ask the instructor questions during class	1	2	3	4	5
4m	Preview concepts before class by reading, watching videos, etc.	1	2	3	4	5
4a	Listen to the instructor lecture during class	1	2	3	4	5
4s	Watch the instructor demonstrate how to solve problems	1	2	3	4	5
4k	Get most of the information needed to solve the homework directly from the instructor	1	2	3	4	5
4n	Solve problems in a group during class	1	2	3	4	5
4u	Do hands-on group activities during class	1	2	3	4	5
4i	Discuss concepts with classmates during class	1	2	3	4	5
4d	Work in assigned groups to complete homework or other projects	1	2	3	4	5
4l	Be graded based on the performance of my group	1	2	3	4	5
4g	Study course content with classmates outside of class	1	2	3	4	5
4j	Make and justify assumptions when not enough information is provided	1	2	3	4	5
4c	Find additional information not provided by the instructor to complete assignments	1	2	3	4	5
4r	Take initiative for identifying what I need to know	1	2	3	4	5
4b	Brainstorm different possible solutions to a given problem	1	2	3	4	5
4h	Assume responsibility for learning material on my own	1	2	3	4	5
4t	Solve problems that have more than one correct answer	1	2	3	4	5