Attitudes of in-service physics teachers towards a constructivist professional development workshop

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Abstract

In this report we describe a qualitative research study of the attitudes of 39 in-service university physics teachers towards active learning teaching strategies presented in a workshop. This professional development workshop was designed following a constructivist approach to pedagogical and disciplinary development, based on the results of physics education research. According to social psychology, attitudes are integrated by three components: cognitive, behavioral and emotional; and those attitudes can be expressed by opinions. Therefore, through this research we try to answer the question: What are the attitudes towards active learning strategies that show in service physics teachers attending a professional training workshop? Using normalized gain of a multiple choice conceptual test, the cognitive component was indirectly assessed. Behavioral and affective components were assessed through content analysis of an open-ended survey applied to the end of the workshop and individual and collaborative reflection made for each topic of the workshop. From the 243 meaningful phrases emerged ten different themes. This report presents some preliminary results, some limitations of this type of study as well as suggestions for further research

Keywords: Attitudes, active learning, preconceptions, normalized gain.

Resumen

En este artículo de investigación cualitativa se describen las actitudes de 39 profesores en ejercicio hacia las estrategias de aprendizaje activo presentadas en un taller con un enfoque constructivista desarrollado en base en los resultados de investigación educativa en la física. De acuerdo con la psicología social las actitudes se integran por tres componentes: cognitivo, conductual y afectivo y se pueden manifestar a través de las opiniones por lo que está investigación respondió a la pregunta ¿Cuáles son las actitudes hacia las estrategias de aprendizaje activo que manifiestan los profesores de física en ejercicio que asisten a un taller de actualización? Utilizando ganancia normalizada se evaluó de forma indirecta el componente cognitivo utilizando un test conceptual de opción múltiple, los componentes conductual y afectivo se evaluaron a través de análisis de contenido con una encuesta de respuesta abierta aplicada al final del taller y con la reflexión individual y por equipos realizada para cada tema. De 243 frases significativas emergieron diez temas. Se presentan resultados preliminares así como las limitaciones de este tipo de estudios y sugerencias para futuras investigaciones.

Palabras clave: Actitudes, aprendizaje activo, preconcepciones, ganancia normalizada.

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I. INTRODUCTION

Attitudes towards science, learning, and social impact are increasingly important [1]. In this work we propose to study the attitudes towards active learning strategies shown by in-service physics professors attending a professional training workshop. According to Vasquez and Manassero [2], social psychology states that attitudes comprise three components: cognitive, behavioral and emotional, so this research analyzes these components with different instruments. First we study the cognitive component of learning through the achieved disciplinary knowledge. Then, making use of content analysis techniques we analyze their perceptions towards active learning teaching strategies and their ideas about student preconceptions regarding the subject matter of the workshop, namely the more common topics of electricity and magnetism. The study is complemented with the participants' points of views about the workshop and the teaching strategies presented. The structure of professional development teacher workshop has been designed according to the constructivist model of short teacher training courses previously presented by Benegas, Zavala and Alarcón [3]. It is important to note that that the emphasis of the workshop was on the presentation of active learning teaching strategies, *i.e.*, it was addressed toward

pedagogical content knowledge, and not toward disciplinary or content knowledge.

II. LITERATURE REVIEW

Active learning methodologies based on the results of Physics Education Research in recent years have proven to be very effective in increasing conceptual understanding of physics [4]. Their appropriate application requires, however, a teacher´s attitudinal change, which must leave his/her role of knowledge authority and assume a facilitator role. This change in teacher's attitude is not the only factor influencing the transition from passive to active learning. It also involves other cultural factors that may differ from country to country, but it is clear that teacher disposition influences both the acceptance of the strategy and the willingness to use it [1]. Attitudes toward science among students have become increasingly important as reflected in the literature review of Osborne [5], which reveals the importance of promoting positive attitudes toward science.

Active learning strategies promote such positive attitudes in students when they engage in their own learning process and have the opportunity to see the relationship of physics to the real world. Research on teachers' attitudes toward science is much less abundant, according to some work, especially regarding the science, technology and society (STS) Approach [6]. These were among the reasons that motivated us to investigate teachers' attitudes toward active learning strategies. In this study we consider that points of view are precursors of attitudes, that is, a point of view reflects the attitude towards certain subject. Teacher's beliefs are reflected, in a practical manner, in their teaching preferences [7]. Recent research [8, 9, 10] has found that teachers' beliefs about the nature of science and how they conceive learning influence their instructional practices. In this study we propose to inquire about the attitudes towards active learning strategies held by physics teachers after experiencing themselves the characteristics and effectiveness of these teaching strategies.

III. THE EXPERIMENT

A. Sample

The sample was determined by the organizers of the workshop. It consisted of 39 physics teachers (about 50% female) that attended the 3rd. Regional Southern Cone Workshop on Active Learning: Electricity and Magnetism (AAEyM-Córdoba 2010) and the 3rd Regional Conference of the Southern Cone on Active Learning Physics (CRAAF-3) [11]. Of the 39 registered participants at the workshop, we selected the evidence of 26 participants who completed pre- and post-tests of the conceptual test for the calculation of normalized gain [12]. Participants have diverse backgrounds, including several with Ph. D. in Physics. 25 of the 26 participants reported in this study are presently teaching.

B. Instruments

To assess the conceptual learning of the topic the Conceptual Survey of Electricity and Magnetism (CSEM) was chosen [13]. The results were analyzed to determine the levels of conceptual understanding of the topics of electricity and magnetism at the beginning (pre-test) and end (post-test) of the workshop. Then, the normalized gain could be determined [12]. The perceptions of the strategies were collected through a survey of seven open questions. The analysis of the responses was made by the techniques of content analysis [14]. We analyzed all the 39 available surveys. Since they were completed anonymously, they could not be correlated with other information. Finally, teachers were asked to elaborate daily reflections on the learning difficulties and preconceptions they have seen in their own students regarding the subject matter of the day. The analysis of written reflections was made also by content analysis.

C. Procedure

At the beginning and at the end of the course the participants were given the conceptual multiple-choice test CSEM. Giving then Pre-/post-instruction CSEM tests were presented as a practical example of a controlled instruction, using a conceptual test based on educational research on alternative models and learning difficulties to determine success and missing points of a given instruction approach. CSEM has been widely used in both educational research and formative assessment for the purpose of improving instruction [3]. The opinion survey was applied before the post-test of CSEM and each participant answered it individually. At the beginning of each different subject matter teachers reflected on the learning difficulties of their own students on these themes. At the end of the day, the members of each small collaborative group reflected on the effectiveness that the different strategies practiced that day have in handling the learning difficulties of their students. The examination of all these written reflections was made by content analysis.

IV. RESULTS

A. Normalized gain

With the results obtained in the pre-test (72.6%, SD=19.9) and the post-test (79.46%, SD=16.89) the normalized gain was calculated. Normalized gain in the entire test group was 0.249 (g =0.249). According to Hake [12] if these students corresponded to a regular, extended, course, this normalized gain will be considered high for traditionally thought course, but relatively low for active learning strategies. What is remarkable here is that this relatively high gain has been obtained with university professors undergoing a very intensive but short training course. It indicates that participating teachers were able to increase and focus their conceptual disciplinary knowledge about

electricity and magnetism. While this is not usually an explicit goal of professional development courses, and certainly has not been an explicit goal of this workshop, it shows that physics teachers (and any other science teacher) usually finished their pre-service training and even practiced teaching for a few years and still maintain some conceptual difficulties, a known effect due to the persistence of alternative models [15]. This result shows, on the other hand, the effectiveness of active learning strategies in the development and consolidation of conceptual knowledge. Analysis of pre- and post-test, and standardized gain indicates that significant progress was achieved in conceptual knowledge of the different subjects covered by CSEM. The idea of a learning process controlled by measuring both the pre and post instruction conceptual knowledge (pre and post-tests) proved to be attractive to workshop participants as seen for example in opinion survey 10: "From the teaching strategies presented, I will implement: predictions, pre-test and post-test".

B. Content Analysis

B.1. Survey

243 sentences were collected in the first three survey questions that inquired advantages and disadvantages of the three core strategies of the course: Interactive Lecture Demonstrations (ILD) [16], Real Time Physics (RTP) [17] and Tutorials for Introductory Physics [18]. The total sentences from each category were considered 100%, so the percentages shown in the analysis are related to the status and the strategy. Table I shows the percentages of the advantages and disadvantages of three teaching strategies. One can see that *None* was mentioned only in the case of the disadvantages, the teachers were emphatic in saying that were not disadvantages in ILD.

TABLE I. Percentage of advantages and disadvantages of the strategies Tutorials (T), RTP and ILD.

	Advantages			Disadvantages		
	T (%)	ILD (%)	RTP (%)	T (%)	ILD (%)	RTP (%)
Time	0	12	7	29	3	0
Material resources	5	10	2	0	3	40
Clarity of strategy	10	10	27	0	7	0
Student participation	10	18	29	16	10	0
Structure	35	18	18	34	10	8
Cognitive skills	23	13	0	5	10	12
Teacher activity	13	2	0	10	18	5
Group size	2	15	4	3	7	0
Cost	2	2	2	0	7	20
Motivation	0	0	11	3	0	0
None				0	25	5
	100	100	100	100	100	100

Below is a description of each item.

Time: According to the sentences under consideration, it is related to concerns of time needed to complete the strategy in the classroom. Do not include preparation time prior to the activity. 29% of phrases indicated the time needed for the strategy of tutorials is its main disadvantage, as shown in the comment on the survey 9: "It involves a lot of time which is not available because of the size of the programs to cover".

Material resources: It refers to the material resources needed to implement the strategy. 10% of the statements indicate that material resources are considered an advantage in ILD as shown in the survey's comment 29: "Lets you work with fewer resources".

Cost of implementation: It refers specifically to the cost to implement the strategy. Represents 20% of the disadvantages of RTP, with comments such as the survey 24: "High cost of Vernier's equipment or similar."

Student participation: Corresponds to the degree of student involvement that the strategy promotes. Although all are active learning strategies, teachers perceive greater student participation in some of them. In the case of Tutorials, teachers indicated that not all students participate. This disadvantage has been noticed by 16% with comments like that of survey 20: "Not all students work collaboratively".

Structure of strategy: The strategies are based on Educational Research in Physics, but teachers question this. 35% of the benefits of Tutorials are related to structure, as shown in the survey's comment 18: "The structure allows reasoning to reach the concept".

Development of cognitive skills: The teachers expressed points of view on scientific reasoning and learning that promotes each strategy, and were grouped into this topic. In the Tutorials represents 23% of the benefits with comments like the survey 17: "It stimulates reasoning and conceptual development".

Teacher activity: This topic refers about the teachers' role that must be played within the strategy of active learning. In the Tutorials represents 13% of the benefits with comments like obtained in survey 21: "Relief for teacher preparation and conduct of the class" and 11% of the drawbacks with comments such as obtained in the survey 10: "More work for the teacher".

Group size: These are the opinions about the possibility of implementing active learning strategies according to the group size they usually work with. ILD represents 15% of the benefits with comments like obtained in survey 18: "It allows working with a large number of students".

Understanding the aims of each strategy: It refers to teachers' understanding the objectives to be achieved by each strategy. While in the Workshop´s training manual objectives and conditions of use of each teaching strategy have been explicitly established, teachers gave their opinions on this matter. ILD had 8% of disadvantages to consider that "The time for discussion can lead students to get out the focus in question" as expressed in the survey 20.

Motivation: Teachers believe that active learning strategies could influence student motivation. RTP represents 11% of

the benefits with opinions such as obtained in survey 4: "The motivation and the fact of doing".

Teachers were asked about what strategies they would implement in their classroom. 36% said tutorials, followed by video analysis with 15%, ILD was 6%.

B.2. Preconceptions

From the four subjects taught in the workshop, 142 sentences with 336 individual contributions were collected. Each of the four topics was separated for the analysis, and each topic was considered as 100%.

Electrical interactions: It was the first topic teachers covered and probably that influenced the results since the individual reflections of the teachers did not show a depth description of the preconceptions. They focused their attention to indicate which topic is more difficult to understand for their students. The most difficult issue is the concept of electric field with a frequency of 15% followed by the concept of electric potential with 13%. It was also possible to observe that in this day of reflection, students' difficulties were associated with their preparation, and understanding mathematical processes together, accounting 15% of the difficulties. The most useful strategy reported was Tutorials for this subject with 33%, followed by RTP with 24%.

Circuits: On the second day descriptions of the preconceptions were clearer than the descriptions of the first day. 15% of the sentences obtained, reported that their students found that current spent is a misconception. Working with mixed circuits also represents 15% of the difficulties. The strategy considered most effective for change the preconceptions of this topic was RTP with 53%, followed by tutorials with 34%.

Magnetic interactions: The main difficulty for the students, represented by 19%, was to understand the magnetic field, followed by the vector character of that field with 13%. Students believe that magnetic poles are equal to electrical charges with 10% frequency. The strategy considered the most effective for the preconceptions of this topic was Tutorials with 63% followed by LDI with 30%.

Electromagnetism: Understanding the meaning of the induced current is the main difficulty in this area with 16%. There was more diversity on the preconceptions than in any other subject. Interestingly, unlike other topics in which the workshop core strategies were those which had the highest percentages for most effective, in electromagnetism the most effective strategy, according to teachers, was Simulations with 29% followed by Tutorials and ILD showing same percentage of 21%. It also shows that having completed training in various active learning strategies teachers were able to propose sequencing strategies to achieve higher learning. 13% of the statements indicated that the most effective strategy is to use more than one active learning strategy.

V. DISCUSSION

The normalized gain value obtained suggests that active learning strategies developed in the workshop appears to be effective to enhance participants´ conceptual knowledge on the different subjects covered by CSEM. This increase was achieved by practicing with the teaching materials intended for students use. This is a remarkable aspect of this workshop, the combined treatment of so-called disciplinary knowledge and methodological knowledge or teaching.

The practice of controlled instruction, with measures of knowledge before and after instruction was appreciated by participants as an essential element of the improvement process.

The learning constructivist approach, addressed by all teaching strategies, favored teachers to experience the difficulties that their students may confront. The analysis of the different phrases of the participants of the difficulties of applying these strategies in their own teaching context and about the value of the teaching strategies, show how seriously they are considering implementing them.

These teachers, on the other hand, showed difficulties to identify the alternative models of their students' thinking. In the most cases, they merely indicated which points they considered of greater difficulty for their students, but failed at describing the confusion or misconception of the various concepts involved. This would indicate that the proposed vision OF the workshop, recognizing the difficulties of students' learning and work on them, is not common for these participants, perhaps a logical consequence of the traditional teacher education and also of the normal teaching practice, focused on what the teacher says rather than of what students learn. It is surely part of the complex process of the change in attitude that is so necessary to effectively implement active learning strategies.

VI. IMPLICATIONS

In previous research, the effectiveness of this workshop format for in-service physics teachers was evaluated [3], and there are several results of the effectiveness of active learning strategies with students in regular university courses [15]. Some of the disadvantages of the teaching strategies used in this workshop, as pointed out by the participants, should to be considered in future workshops. Although many of them are related to the difficulty of obtaining equipment, materials and other economic resources, some are focused on the beliefs of the nature of science and the process of learning. For example, those related to consider that some students will have difficulties that prevent them to take advantage of active learning strategies.

It is important to ensure that the teacher not only leave the workshop convinced about the effectiveness of teaching strategies, but also regarding the advantages for their own professional development by using teaching strategies which development have been based on scientific research and not only on teaching experience.

VII. CONCLUSION

The format implemented in this workshop on active learning strategies clearly resulted in a valuable amount of participant reflections about the characteristics of each strategy and the possibilities of implementing them in their own Teaching context.

In the opinion survey, it was possible to note that teachers need to understand more deeply the objectives and conditions of application of each teaching strategy. This points out to the convenience of improving that part of the workshop training manual.

For the characterization of alternative models of the students, we noticed that teachers were limited most of the time to mentioning the concepts that they think are the most difficult for their students, without identifying the learning difficulties and alternative model. Obviously, this vision of the teaching-learning process is not usual to them, and we think it is part of the process of change that is a necessary condition for the successful implementation of any educational reform based on active learning strategies.

Finally it seems convenient for future research to develop an instrument to measure characteristics about active learning teaching strategies to complement the surveys about conceptual learning. It is also suggested to measure the beliefs about the nature of science and science learning because according to Tsai [10]. These may be mediating variables [19] in the decision to implement or not the active learning strategies.

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