Training to Teach Experimentation with a Metrological Physics bias

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QVO NON ASCENDAM?

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Abstract

We present how a virtual learning environment that specifies contents, objectives and metrological concepts, can provide in-service training to new teachers sharing the course with the authors. Specifically, the virtual environment gives them the opportunity to get acquainted in advance with the course material, decreases his or her anxiety with some parts and topics of the course, helps them to participate more fully in it and to tackle the course in a collaborative spirit which helps students to positively assume their own team work in the lab.

Keywords: Research in physics education, Use of Information technology in teaching science, Active learning of science.

Resumen

Presentamos cómo un ambiente de aprendizaje virtual que especifica contenidos, objetivos y conceptos metrológicos, proporciona entrenamiento a profesores nuevos que comparten el curso con los autores. Específicamente, les brinda la oportunidad de conocer de antemano el material del curso, disminuye su ansiedad con relación a algunas partes y temas del mismo, les ayuda a participar más en él y a asumirlo con un espíritu de colaboración, que facilita a los estudiantes a adoptar positivamente su propio trabajo en equipo en el laboratorio.

Palabras clave: Investigación en enseñanza de la física, Uso de la tecnología de la información en la enseñanza de la ciencia, Aprendizaje significativo de la ciencia.

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I. ANTECEDENTS

At the Basic Science and Engineering Division of the UAMI courses of initiation to experimental work with basic metrology concepts are offered to pupils of the second and third trimesters of the Basic Trunk, common to all the Division curricula. Two professors from different departments of BSE share the teaching, usually from those of Physics and Chemistry, modality which started in 1998 and since then we have given some training for teachers to teach the Experimental Method I and II courses.

The objective of these courses is to offer students an harmonious work environment where they acquire basic skills of observation, knowledge and correct use of measurement instruments, estimation and calculation of the propagation of uncertainties, graphical analysis, determination of empirical models for the studied phenomena, their comparison with theoretical models and the determination of relevant parameters derived from the experimental work, paying special attention to get students to learn to word technical reports in which they clearly communicate the work performed, identifying its relevance and the quality of measurements.

In the Physics department we are aware that, because pupils are young freshmen in the university, it is important for us professors to offer all of our attention and experience in order for them to achieve their adaptation to the academic environment and acquire the necessary knowledge to become successful professionals capable of solving the problems of their time [1].

Often, in the Experimental Method courses one of the professors lacks experience in teaching experimentation and metrology and the course thus becomes a challenge for the professor with little expertise. In addition to interterm workshops, these professors usually extend their training by watching and trying to adapt and support the way topics are presented by the more experienced professor, through the interaction with him or her and the pupils, and profiting from whatever materials are available on the course.

II. BACKGROUND

We follow the cooperative learning approach which is an educational modality for working, learning and teaching for

students and teachers which profits from advances in science such as the Information and Communication Technology ICT as well as research about mediation processes in the classroom. Accordingly, the educator's work is more professional in the measure in which it relies on science and counts on a method, since his activity must be endorsed by science and the scientific method. Proceeding scientifically allows a better understanding of what is being done, facilitates communication between professors sharing the responsibility of teaching and the pupils who learn, generates confidence in applying critically and responsibly previously tested material that diminishes the possibilities of failure, offering alternative scenarios, contingencies are foreseen and decisions are made when the accomplishment of educative objectives may be at risk, increases the control of the whole educative process and, in each of its parts, helps to systematize the work done, appraising successes and insufficiencies, and warrants results according to the conception, method and strategies used [2, p.11].

We are interested in mediating between the pupil and the learning content to improve his progress in the development of his observing, classifying, analysis, reflection, decision and conclusion making, obtaining skills through the interaction and interchange with his peers [3]. We try to favor the development of thinking abilities to discover and study phenomena and to apply creative and innovative strategies that contribute to transform the environment of our pupils.

Promoting peer cooperation to achieve learning implies to direct pupils to act jointly with each other to reach a common goal. This requires attaining that students take part in their teaching-learning process [2, p. 42].

To attain a personalized attention in the group we need to resort to distinct strategies with ways of organizing teaching that favor each and every pupil in the class. We search for every student to have the chance to show his talent in a given moment, which will help him to have a better self-perception towards studying. Cooperative learning requires every lesson to be structured with different moments and teaching strategies to favor using the whole brain, intensifying and diversifying the participation of pupils in class [2, p. 51].

The facilitator's role demands our relation with students to favor their learning, stimulate the development of their potential, correct deficient cognitive functions, propitiating the pass from an initial state of not knowing, not doing and not being to other qualitatively superior of knowing, doing and being, i. e., to offer them the required help for them to reach the zone of potential development. Thus, our intention must be clear, and we should promote reciprocity and stress the transcendence of the present moment.

The mediating tasks (facilitation) require to reach a mutual activity-communication relationship (reciprocity) in which both mediator and pupil participate actively in search of learning; having very clear what we want to accomplish and how (intentionality); help the pupil to find the tasks' meaning and therefore to make them his or her own (meaning); project into the future the relevance of the work in class going beyond the present; create a new system of needs that move pupils to later actions (transcendence); awake in them the confidence that they are able (self-esteem) and the regulation of impulsivity, so that they manage to think before acting [2, p. 56].

Cooperation occurs when one of the team members perceives that he may accomplish the goal if, and only if, all of them work together and everyone puts his share. As facilitators, we must promote that the cooperative interrelation among classmates gives them chances to do, say and feel; support them according to the needs they show, growing expectations, constant positive reinforcement; different perspectives on the same topic; models that they can imitate; development of cognitive, social and affective skills [2, p. 58].

Learning is a consequence of thinking. Retention or memory, comprehension and active use of knowledge can only be accomplished by learning experiences in which pupils think on and with whatever they are learning [4, p. 104]. Without an emphasis on thinking, reaching a deep understanding of contents is practically impossible. Teaching to think, quite difficult task in this stage of life, underscores the student's autonomy and independent enquiry. We also know that the sensations of control and of competence are essential to motivate students [5, 6].

Since we work towards accomplishing successful professionals in science and engineering, we are also interested in helping them develop a critical thought, i. e., that they have the ability and disposition to reach conclusions and to evaluate them based on proofs, confirming conclusions with facts, identifying the implicit suppositions, recognizing excessive or too tenuous generalizations, identifying the relevant and irrelevant information, as well as biases, stereotypes, clichés and propaganda to correctly eliminate them [4, p. 107].

We have oriented students in search of autonomous learning for them to develop competences to face challenges, solve problems and interact with others [7].

Considering that the cause of failure and difficulties pupils face to succeed in the experimentation labs is multifactor, as Marchesi and Pérez [8] assert, we designed with Moodle some resources of a virtual classroom that allow us to pay attention to some of those aspects, such as the professors' training and incentives, teaching time, curricular flexibility, continuous attention to the pupils' needs, improvement of their motivation, expectations and dedication to work and to offer them the means for self-assessment of the process throughout the course.

A. Individual work

Teachers' personal work and commitment are essential to advise students in experimental work and the course topics, to clarify doubts, coordinate activities, strategies and experiments, to support students in discussion forums proposing topics of interest to all; apply classroom strategies for solving specific problems; evaluate and verify the effectiveness of their proposals and teaching strategies,

share their findings and concerns about the course and students' performance with the other teacher.

B. Cooperation

Aware of the importance of cooperation to achieve meaningful learning in students, a common duty is to combine efforts, creativity and experience to promote it in the laboratory [4, 5, 6]. Discussion forums are excellent means for collective reflection and deepening of knowledge from the concrete teaching and learning situation in the classroom and encourage the commitment to become agents of change in acquiring personal and collective knowledge of science.

III. VIRTUAL ENVIRONMENT EFFECTS

To complement presencial sessions in the lab, we took advantage of Moodle's resources to build a virtual classroom where concepts are discussed, training is given in information search and in planning the experimental activities, in using measuring instruments and carrying out complete experimental activities, including the numerical and graphical data analysis, obtaining final results and comparing them with values reported in the literature and writing technical reports [9].

FIGURE 1. Part of the principal web page in Moodle platform supporting the lab class.

In Fig. 1 the numbers on the left side indicate the session when topics indicated in the central column are seen. The rightmost column shows tasks sent by pupils on the dates and times shown. This information is very useful for the teachers, allowing us to know which pupils are sending their work on time and who didn't. Identifying the difficulties that they had to do their work right away allows us to help them with appropriate directions.

Links to the objectives, contents and way to evaluate the course are included in the first session, for both pupils and teachers to be aware of its planning, relevance, and conduction and evaluation rules. This information turns out to be very useful for pupils and teachers to organize our time and get ready to carry forward a neat trimester with a well defined work method.

Figure 2 shows an example of the contents pages dealing with measuring instruments, their characteristics and types.

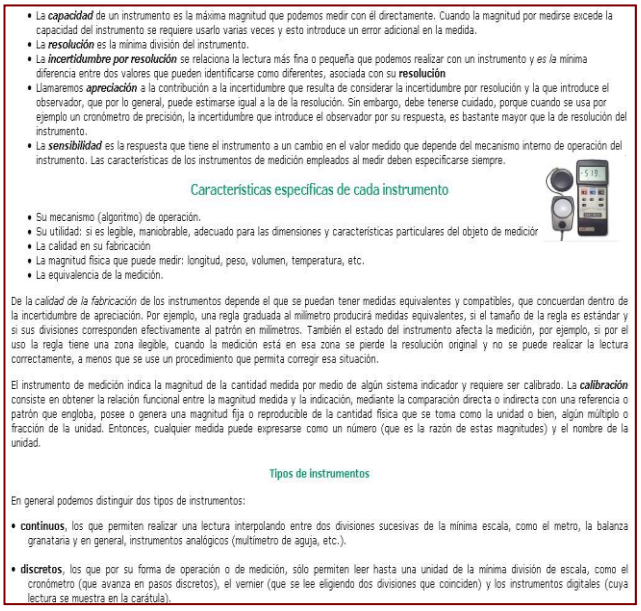


FIGURE 2. View of piece of web page for *Measuring Instruments*.

The fact that the contents are on the web site eases the development of support materials such as questionnaires and exercises that encourage the students' meaningful learning.

In the first week of the trimester a diagnostic evaluation is applied to students on the items that they should know as a prerequisite to reach a good achievement in the experimentation course. Fig. 3 shows some impressions of students about how they felt finishing it and what they planned to do to correct their deficiencies.

FIGURE 3. Sample of forum: Impressions on the diagnostic evaluation.

Among the views expressed is that of changing their idea of their capability and to strive to fill information gaps in order to be better prepared. Also shown is the accompanying of the teacher, who helped the students to overcome their discomfort and take positive steps to properly correct the situation.

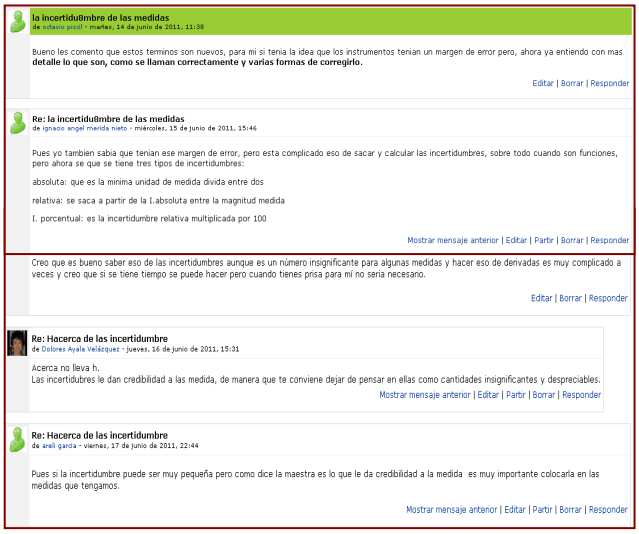


FIGURE 4. Sample of forum: Measurement uncertainty.

Figure 4 shows another example of the students' exchange at the forum on the uncertainty of measurements. In this forum, teachers can recognize in addition to spelling difficulties, a form of expression with generalities from the first student and the second one specifying concepts, while the third shows his reticence to learn the propagation of uncertainties because he still does not catches on its relevance and a fourth classmate who told that although small, they are important and encouraged him not to skip them. This is very useful information for teachers because it reveals that some students have not understood the usefulness of determining the uncertainty of measurements, allowing us to reinforce the concept and its use with new exercises directed to clearly demonstrate their relevance.

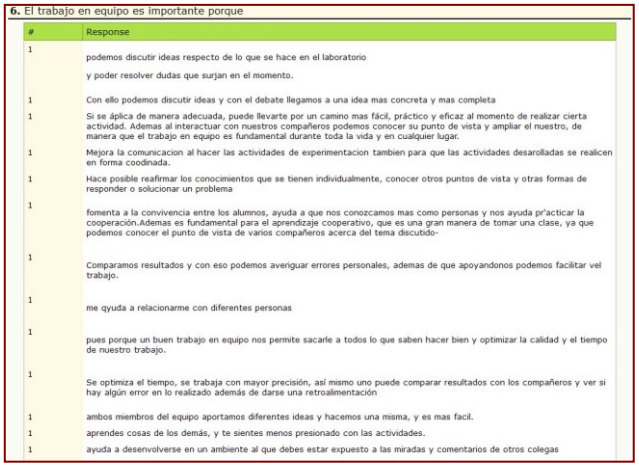
FIGURE 5. Sample of forum: Experimental Method.

Since the focus of the course is experimental method, in Fig. 5 we show a part of the exchange of views on the subject held by 44 students from two of the groups taught by the authors. The first part shows the exchange between a student and one of the teachers of the course, who helps her to place the issue more clearly, to which the student responds very gratefully. In the second part a student comments on his impressions about the course and his feelings about not reaching good grades and some classmates who agree with him on his findings, look for ways to encourage him and lead him to identify that a useful means is the reciprocal support among the classmates. Notice that the different teachers' participations in the forums of Figs. 4 and 5 are complementary.

FIGURE 6. Sample of poll: Personal progress.

Other very useful resource of the virtual page are the questionnaires that can be used as a way of knowing the students' opinion about different subjets (polls) or as formative evaluations of their progress in their learning. Fig. 6 shows a sample of the first type with the opinion of two students about what they need to do in order to fullfill the course rhythm and covering all its aspects and requirements including working in the Moodle pages and their own iniciative participating in lab classes. These answers also contrast the pupils' comunication styles, one with concrete proposals and intentions and the other with more general and vague ideas. This information lets us try to help the student who deals with generalities to stablish concrete goals to let him achieve his purposes.

In Fig. 6 one finds that the two students who answered think that investigating and studying the topics in advance and having an open mind help them to collaborate; that planning, organization and order prevent mistakes and help to finish their tasks on time; that Moodle helps them to be organized and do a more orderly work.



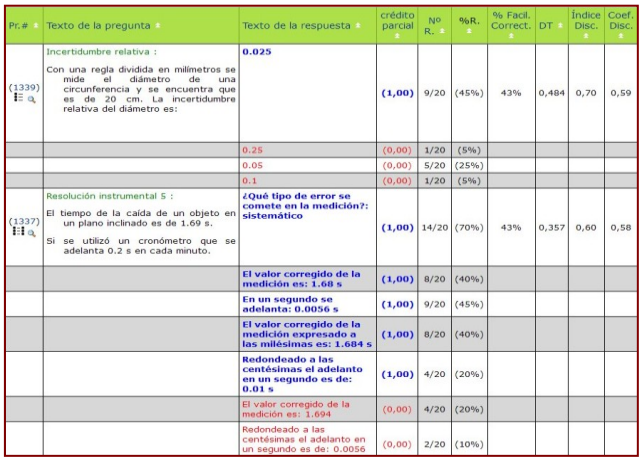
6. El trabajo en equipo es importante porque

#	Response
1	podemos discutir ideas respecto de lo que se hace en el laboratorio y poder resolver dudas que surjan en el momento.
1	Con ello podemos discutir ideas y con el debate llegamos a una idea mas concreta y mas completa
1	Si se áplica de manera adecuada, puede llevarte por un camino mas fácil, práctico y eficaz al momento de realizar cierta actividad. Ademas al interactuar con nuestros compañeros podemos conocer su punto de vista y ampliar el nuestro, de manera que el trabajo en equipo es fundamental durante toda la vida y en cualquier lugar.
1	Mejora la comunicacion al hacer las actividades de experimentacion tambien para que las actividades desarolladas se realicen en forma coodinada.
1	Hace posible reafirmar los conocimientos que se tienen individualmente, conocer otros puntos de vista y otras formas de responder o solucionar un problema
1	fomenta a la convivencia entre los alumnos, ayuda a que nos conozcamos mas como personas y nos ayuda pr'acticar la cooperación.Ademas es fundamental para el aprendizaje cooperativo, que es una gran manera de tomar una clase, ya que podemos conocer el punto de vista de varios compañeros acerca del tema discutido-
1	Comparamos resultados y con eso podemos averiguar errores personales, ademas de que apoyandonos podemos facilitar vel trabajo.
1	me qyuda a relacionarme con diferentes personas
1	pues porque un buen trabajo en equipo nos permite sacarle a todos lo que saben hacer bien y optimizar la calidad y el tiempo de nuestro trabajo.
1	Se optimiza el tiempo, se trabaja con mayor precisión, así mismo uno puede comparar resultados con los compañeros y ver si hay algún error en lo realizado además de darse una retroalimentación
1	ambos miembros del equipo aportamos diferentes ideas y hacemos una misma, y es mas facil.
1	aprendes cosas de los demás, y te sientes menos presionado con las actividades.
1	ayuda a desenvolverse en un ambiente al que debes estar expuesto a las miradas y comentarios de otros colegas

FIGURE 7. Sample of poll: Team work.

Figure 7 shows the opinions at the begining of the course of 11 of the 25 students who answered about working as a team. All of them coincide in the importance of working together in order to achieve the goals of the course and of exchanging ideas in order to get a common one that might help them solve specific problems and aspects of the course. Finally, they commented that in the experimental activity they started to learn to work as a team, to measure, to speed up their work and recognize the need of self-confidence to make questions right away in order to clarify doubts.

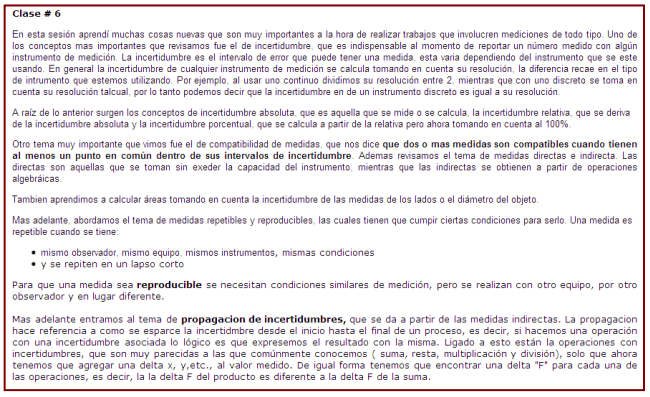
A part of the results of a formative evaluation containing uncertaintites, systematic error and round up is shown in Fig. 8. The blue text in the third column denotes the right answers while the red text are the wrong answers. In the fifth and sixth columns we find the number and percentage of students who chose either answer. Formative evaluations such as this are meant to let each pupil identify what he correctly knows or what concepts or ideas are not clear. Pupils can repeat them a preset number of times along the course until ideally he/she is satisfied with the results. Besides indicating to each pupil if his answer to any question was right or wrong, these results are very valuable for the teachers to identify the topics in which pupils need clarification or additional activities to achieve a good understanding.



Pr.#	Texto de la pregunta	Texto de la respuesta	crédito parcial	Nº R.	%R.	% Facil. Correct.	DT	Índice Disc.	Coef. Disc.
(1339)	Incertidumbre relativa : Con una regla dividida en milímetros se mide el diámetro de una circunferencia y se encuentra que es de 20 cm. La incertidumbre relativa del diámetro es:	**0.025**	**(1,00)**	9/20	(45%)	43%	0,484	0,70	0,59
		0.25	(0,00)	1/20	(5%)				
		0.05	(0,00)	5/20	(25%)				
		0.1	(0,00)	1/20	(5%)				
(1337)	Resolución instrumental 5 : El tiempo de la caída de un objeto en un plano inclinado es de 1.69 s. Si se utilizó un cronómetro que se adelanta 0.2 s en cada minuto.	**¿Qué tipo de error se comete en la medición?: sistemático**	**(1,00)**	14/20	(70%)	43%	0,357	0,60	0,58
		El valor corregido de la medición es: 1.68 s	**(1,00)**	8/20	(40%)				
		En un segundo se adelanta: 0.0056 s	**(1,00)**	9/20	(45%)				
		El valor corregido de la medición expresado a las milésimas es: 1.684 s	**(1,00)**	8/20	(40%)				
		Redondeado a las centésimas el adelanto en un segundo es de: 0.01 s	**(1,00)**	4/20	(20%)				
		El valor corregido de la medición es: 1.694	(0,00)	4/20	(20%)				
		Redondeado a las centésimas el adelanto en un segundo es de: 0.0056	(0,00)	2/20	(10%)				

FIGURE 8. Part of a formative evaluation results on instrumental uncertainties.

We used personal wikis for the pupils to write a diary describing what they are learning in each of the sessions, which requires from them a great deal of attention and effort to recognize. Fig. 9 shows a sample from such a pupil's diary for session # 6. He recalls uncertainties, compatible measurements, repeatability conditions, reproducibility, and propagation of uncertainties. Since the format is completely free, this use of wikis lets pupils point out, in their own words, what they understood, what they thought or felt, etc. They are a practical means for the teachers to supervise their learning or lack thereof and to act accordingly.



Clase # 6

En esta sesión aprendí muchas cosas nuevas que son muy importantes a la hora de realizar trabajos que involucren mediciones de todo tipo. Uno de los conceptos mas importantes que revisamos fue el de incertidumbre, que es indispensable al momento de reportar un número medido con algún instrumento de medición. La incertidumbre es el intervalo de error que puede tener una medida, esta varia dependiendo del instrumento que se este usando. En general la incertidumbre de cualquier instrumento de medición se calcula tomando en cuenta su resolución, la diferencia recae en el tipo de intrumento que estemos utilizando. Por ejemplo, al usar uno continuo dividimos su resolución entre 2, mientras que con uno discreto se toma en cuenta su resolución talcual, por lo tanto podemos decir que la incertidumbre en de un instrumento discreto es igual a su resolución.

A raíz de lo anterior surgen los conceptos de incertidumbre absoluta, que es aquella que se mide o se calcula, la incertidumbre relativa, que se deriva de la incertidumbre absoluta y la incertidumbre porcentual, que se calcula a partir de la relativa pero ahora tomando en cuenta al 100%.

Otro tema muy importante que vimos fue el de compatibilidad de medidas, que nos dice **que dos o mas medidas son compatibles cuando tienen al menos un punto en común dentro de sus intervalos de incertidumbre**. Ademas revisamos el tema de medidas directas e indirecta. Las directas son aquellas que se toman sin exeder la capacidad del instrumento, mientras que las indirectas se obtienen a partir de operaciones algebráicas.

Tambien aprendimos a calcular áreas tomando en cuenta la incertidumbre de las medidas de los lados o el diámetro del objeto.

Mas adelante, abordamos el tema de medidas repetibles y reproducibles, las cuales tienen que cumpir ciertas condiciones para serlo. Una medida es repetible cuando se tiene:

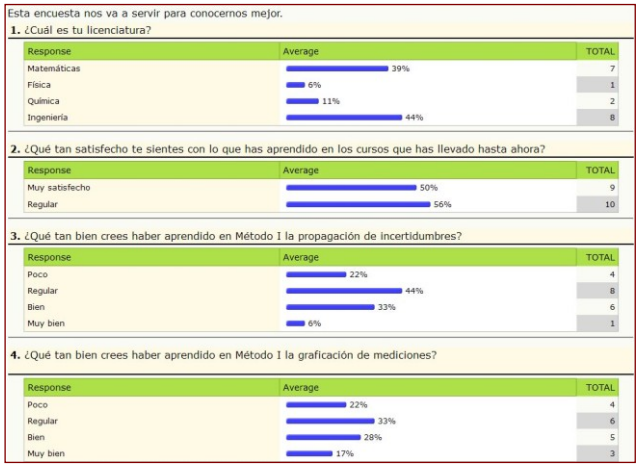
- mismo observador, mismo equipo, mismos instrumentos, mismas condiciones
- y se repiten en un lapso corto

Para que una medida sea **reproducible** se necesitan condiciones similares de medición, pero se realizan con otro equipo, por otro observador y en lugar diferente.

Mas adelante entramos al tema de **propagacion de incertidumbres,** que se da a partir de las medidas indirectas. La propagacion hace referencia a como se esparce la incertidmbre desde el inicio hasta el final de un proceso, es decir, si hacemos una operación con una incertidumbre asociada lo lógico es que expresemos el resultado con la misma. Ligado a esto están la operaciones con incertidumbres, que son muy parecidas a las que comúnmente conocemos (suma, resta, multiplicación y división), solo que ahora tenemos que agregar una delta x, y,etc., al valor medido. De igual forma tenemos que encontrar una delta "F" para cada una de las operaciones, es decir, la la delta F del producto es diferente a la delta F de la suma.

FIGURE 9. Sample of a wiki: My Experimental Method Diary.

Samples of a poll applied to pupils enrolled in an Experimental Method II group to let teachers identify pupils' majoring field and their knowledge or competence on various items covered in their previous Experimental Method I courses are shown in Fig. 10. The first answer shows the distribution of the students' intended major, information very useful for teachers to select and direct class activities. A very important datum for us is that a large proportion of students acknowledge their imperfect handling of the propagations of uncertainties, graphing measurements and applying graphical analysis, which prompted us to explain these topics in the class whenever they were to be required.


Esta encuesta nos va a servir para conocernos mejor.

1. ¿Cuál es tu licenciatura?

Response	Average	TOTAL
Matemáticas	39%	7
Física	6%	1
Química	11%	2
Ingeniería	44%	8

2. ¿Qué tan satisfecho te sientes con lo que has aprendido en los cursos que has llevado hasta ahora?

Response	Average	TOTAL
Muy satisfecho	50%	9
Regular	56%	10

3. ¿Qué tan bien crees haber aprendido en Método I la propagación de incertidumbres?

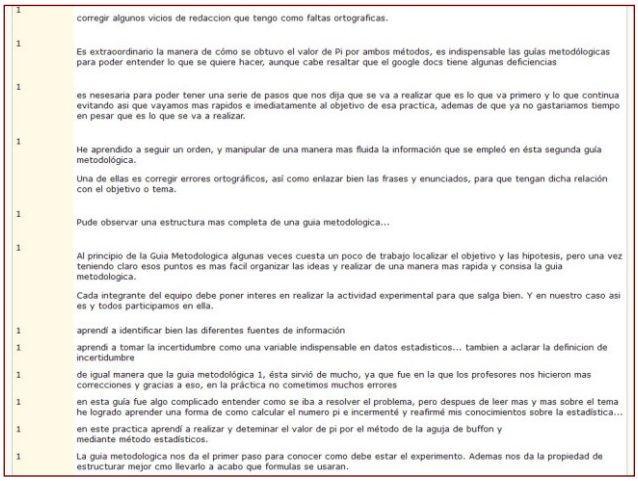
Response	Average	TOTAL
Poco	22%	4
Regular	44%	8
Bien	33%	6
Muy bien	6%	1

4. ¿Qué tan bien crees haber aprendido en Método I la graficación de mediciones?

Response	Average	TOTAL
Poco	22%	4
Regular	33%	6
Bien	28%	5
Muy bien	17%	3

FIGURE 10. Sample of a poll: Personal knowledge and opinions.

In Fig. 11 we show some of the pupil´s answers to the question "*what did you learn in writing this methodological guide*" which comes last in a poll built as a checklist for the guide's content. The straightness and frankness of many of the answers may serve the teachers to recognize the terms, concepts or parts of that work needing more discussion or work in class. Some of the comments may refer to the professors' observations added to their work in the writing environment used, for which with the intention to promote collaborative work among the working team's members, the authors had suggested to try the text editor of Google Docs.


1 corregir algunos vicios de redaccion que tengo como faltas ortograficas.

1 Es extraordinario la manera de cómo se obtuvo el valor de Pi por ambos métodos, es indispensable las guías metodólogicas para poder entender lo que se quiere hacer, aunque cabe resaltar que el google docs tiene algunas deficiencias

1 es nesesaria para poder tener una serie de pasos que nos dija que se va a realizar que es lo que va primero y lo que continua evitando asi que vayamos mas rapidos e imediatamente al objetivo de esa practica, ademas de que ya no gastariamos tiempo en pesar que es lo que se va a realizar.

1 He aprendido a seguir un orden, y manipular de una manera mas fluida la información que se empleó en ésta segunda guía metodológica.

Una de ellas es corregir errores ortográficos, así como enlazar bien las frases y enunciados, para que tengan dicha relación con el objetivo o tema.

1 Pude observar una estructura mas completa de una guia metodologica...

1 Al principio de la Guia Metodologica algunas veces cuesta un poco de trabajo localizar el objetivo y las hipotesis, pero una vez teniendo claro esos puntos es mas facil organizar las ideas y realizar de una manera mas rapida y consisa la guia metodologica.

Cada integrante del equipo debe poner interes en realizar la actividad experimental para que salga bien. Y en nuestro caso asi es y todos participamos en ella.

1 aprendí a identificar bien las diferentes fuentes de información

1 aprendi a tomar la incertidumbre como una variable indispensable en datos estadisticos... tambien a aclarar la definicion de incertidumbre

1 de igual manera que la guia metodológica 1, ésta sirvió de mucho, ya que fue en la que los profesores nos hicieron mas correcciones y gracias a eso, en la práctica no cometimos muchos errores

1 en esta guía fue algo complicado entender como se iba a resolver el problema, pero despues de leer mas y mas sobre el tema he logrado aprender una forma de como calcular el numero pi e incermenté y reafirmé mis conocimientos sobre la estadística...

1 en este practica aprendí a realizar y deteminar el valor de pi por el método de la aguja de buffon y mediante método estadísticos.

1 La guia metodologica nos da el primer paso para conocer como debe estar el experimento. Ademas nos da la propiedad de estructurar mejor cmo llevarlo a acabo que formulas se usaran.

FIGURE 11. Sample of poll: Methodological guide.

Very fundamental and relevant topics are approached in the Experimental Method I course to direct pupils to their first steps of their professional life, among which writing a formal report, the items that it should include, and especially the importance of knowing how uncertainties are handled, since these are essential to perform a good analysis on the experimental data. Even if students don't clearly visualize how important handling these topics is because they don't see them applied in their profession, it is a good thing that each professor has the enthusiasm to motivate pupils showing them some of the applications that the topics discussed in class have in each of the careers.

IV. RESULTS

As results we present a few teachers' opinions, that show the relevance and effects on them of this project.

«Teaching the course jointly with a colleague from a different department and area is very rewarding, in particular when working with someone who has extensive experience, especially for someone like me, just a beginer in teaching. This is the first time that I teach the course with a person who shows good and creative vision in the group management, addressing the topics in a dynamic way by having students learn to reason, reflect, think, analyze, teamwork and most importantly to discuss in the classroom about the topics and about what each student seeks or pretends to achieve as a professional. It's nice to work like this. I myself, like the students, have learned a lot. Some other colleagues are dedicated to just giving the topics but leaving aside the pupils' awareness of the topics' importance. With two teachers working together in one course, there is the risk that one stays aside while the other transmits knowledge to the students, risk that can be prevented using strategies to share the handling of the group. Regarding the platform, it is a useful tool for both parties, the teacher shares the knowledge with students giving them useful and very important material for each topic. It is easy to use, gives feedback on learning and most

important, one can check the material at any time of day because the information is always available on the portal». M. L. L.

«The information in your virtual classroom seemed very complete to me. The web page about the moments of a distribution is of an excellent level, perhaps a bit steep for students but for teachers it is a very valuable reference material. Likewise the material on least squares, with a different approach from that presented by Baird [10]. The material that you developed for the virtual classroom seems to me much more formal and informative. Regarding the self-assessment questionnaire, I think it is a very useful tool to determine the degree of students' understanding of basic statistical concepts of the course. It would be great to develop questionnaires of that type for the rest of the course». J. P.

«Moodle complements our lab work. In a systematic way, materials in the site help students to be informed about the course objectives, to read on different topics, to practice problem solving and improve their communication abilities with peers and teachers. Students feel free to express their opinion and to evaluate continuously the course. For teachers, it is a way of verifying student's level of advance in knowledge and attitudes towards their work and to the others». G. S.

V. CONCLUSION

The use of a virtual environment helps prevent the reduction of the course to a conventional one, focusing in the formation of professionals who are able to solve problems putting together and using the knowledge gained throughout their educational life. In these courses we pretend to teach students to create, design, understand, analyze, discuss and resolve issues in an amusing and innovative way. In so doing, one has to work very hard and learn a lot, first, to put the site together and give it reasonable maintenance, and latter, to be sensitive enough to respond to the students' needs that we recognize in the platform's various resources and work to fulfill them.

Disponibility of different materials and formative evaluations of the course in the virtual page, help beginner teachers to: get acquainted with those materials; to know students' needs along the term in order to offer them opportune personal or groupal attention; introduce changes and adjustments to the order of presentation of topics; be flexible and creative; direct students to search for complementary information and to complete Moodle activities and tasks; permanent review of its materials with the possibility of improving them with links and new information.

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