

2.3 “Can You Listen to My Voice?” Including a Student Voice in the Design of a Chemistry Module Aiming to Increase Students’ Learning and Motivation

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Abstract

Science education has been criticized for failing to motivate young learners to learn science. This could be partially attributed to that even though curricula are designed for students, students’ views are often excluded from the curriculum design process. However, even though listening to students’ voices may result to more effective science curricula, such an approach has been barely practiced and has not received much empirical exploration. This work reports on a case study examining the development of inquiry-based module; participants included nine high school chemistry teachers (members of the PROFILES Cyprus 2012-13 professional development program) and their students who were consulted on their views regarding an ideal learning environment. The participatory design process adopted consisted of three separate parts: (a) the collection and analysis of students’ perspectives, (b) the development of the inquiry-based learning environment based on students’ views and (c) the implementation and evaluation of the learning environment. Empirical evidence indicates that the designed learning environment, which took students’ perspectives into account, resulted to substantial learning gains in terms of increased conceptual understanding and motivation.

Introduction

During the last decades, science education stakeholders have made several efforts to explore how to improve science teaching, as the literature reports that science education often fails to motivate or to meaningfully engage young learners (e.g. Eurydice network, 2011; EC 2007). Middle school, as well as high school, students seem to be unwilling to learn science and seem to have a lack of interest towards science (e.g. Eurydice network, 2011; Lyons & Quinn, 2010; OECD, 2006). As a consequence, it is not surprising that many students, all over the world do not pursue further science studies (Chubin, Donaldson, Olds & Fleming, 2008; Committee on Science, Education, & Public Policy, 2007; Jacobs & Simpkins, 2005; Sanders, 2008; 2009; Young, 2005).

Traditional science education has been criticized for focusing explicitly on teaching rote facts and scientific concepts, without helping students connect science learning with their own lives (Fensham, 2004; Holbrook, 2003; Osborne & Collins, 2001; Sjoberg, 2001). Fensham (1998) reported on the lack of collecting data on students’ sense of the relevance of the science topics included in the TIMSS achievement tests. Even though young people recognized the importance of science in

society, they often considered science subjects less engaging compared to other subjects (Jidesjö & Oscarsson, 2006; Oscarsson, Jidesjö, Karlsson & Strömdahl, 2009).

If one purpose of science education is to help students appreciate science, then it is of paramount importance to find out why students become disengaged with school science. Reports in the literature indicate that this problematic situation is largely due to a paradox: despite the fact that all curricula are designed for students, students themselves are excluded from the curriculum design process. According to Jagersma and Parsons (2011), questions about how and what to teach to students have been asked for decades; however, these questions have seldom been posed directly to students. This exclusion can have a negative impact on the learning processes since learners who do not feel connected to the curriculum may pose barriers to their own learning through disruptive practice (Rudduck & Flutter, 2000). In addition, as Könings, Brand-Gruwel and van Merriënboer (2010) have proposed, if students are denied opportunities to communicate their views or guide instructional change, their learning may suffer.

To sum up, listening to student voice and understanding students’ science beliefs may help

the design of more effective science curricula as well as of learning environments that can promote students’ engagement, and thus enhance student learning in science. However, despite the fact that students’ inclusion in the design of science education curricula is more ecologically valid and, potentially, a more sustainable approach for the design of more effective learning environments, it not often practiced. Therefore, according to Jenkins (2006) “*the untested assumption is that the more that is known about students’ interests, enthusiasm, dislikes, beliefs and attitudes, the more feasible it will be to develop school science curricula that will engage their attention [...]*” (p. 51).

This chapter reports on a case study of nine high school chemistry teachers. The teachers participated in the PROFILES Cyprus 2012–13 professional development programme and co-designed an inquiry-based learning environment which was informed by their students’ views regarding an ideal chemistry learning environment. The main aim of the PROFILES project was to familiarize the in-service chemistry teachers with the inquiry-based approach and thus to contribute to their professional development. More specifically, the professional development model used by the PROFILES Cyprus team approach took the form of participatory and collaborative design (Kyza & Nicolaidou, Under Review), according to which nine chemistry teachers jointly designed an inquiry-based learning environment. To listen to student voices, two of the high school chemistry teachers, who were working at the same high school, investigated their students’ perspectives regarding the components of an ideal learning environment that could motivate student chemistry learning.

As a result, in this chapter we report on the following questions:

- (a) What are the students’ perceptions of an ideal chemistry learning environment?
- (b) How are students’ perspectives integrated in the design of an inquiry-based learning environment?
- (c) What is the impact of an inquiry-driven chemistry learning environment, whose design was informed by students, on students’

learning gains?

Theoretical background

The present study was based on the premises of participatory design; more specifically, for the purposes of this study, participatory design includes any initiatives that are based on the involvement of students, as the end users of the design process (Könings et al., 2010). This model is based upon the belief that students’ views of instruction have a direct impact on their learning process, and eventually affect their learning outcomes (Elen & Lowyck, 1999; Entwistle & Tait, 1990).

Students are the primary stakeholders in education and experts on their own experiences (Oldfather, 1995). However, the fact that teachers have usually limited access to their students’ perspectives, results to large differences between students’ and teachers’ perceptions of learning and teaching, and this is likely to threaten the effectiveness of learning (Könings, Brand-Gruwel & van Merriënboer, 2011). Therefore, of paramount importance, may be to bring insights, observations and perspectives of teachers and students together in a dialogue on how the learning and teaching process can be improved. To put it in different words “*Students should help shape rather than simply be shaped by educational policies and practices*” (Cook-Sather, 2003, p. 22). As a result, participatory design aims to promote active participation of the users of any system in the design process as well as in decisions that will have an impact on them (e.g. Berns, 2004; Kensing & Blomberg, 1998).

Research design

In order to investigate the three research questions posed, we collected qualitative and quantitative data depending on the nature of the research question, in combination with the access to and availability of data sources.

First, aiming to investigate 11th grade students’ perspectives regarding an ideal chemistry learning environment, two focus groups were organized by

the two chemistry teachers. Each focus group was composed of twelve 11th graders and discussed such aspects as:

- (a) The factors which could engage or disengage students from a chemistry lesson,
- (b) The components of an ideal chemistry learning environment, and
- (c) Students' suggestions for the enhancement of traditional chemistry instruction.

Each focus group session was lasted 40 minutes, was recorded and subsequently transcribed. Students' perspectives were analyzed qualitatively using Attride-Stirling's (2001) thematic network analysis to identify emerging basic themes. These basic themes were then categorized under an organizing theme. Finally, all of the organizing themes were categorized under the global theme, which, in our case, was an "ideal learning environment in chemistry education."

Second, aiming to investigate how students' perspectives were employed for the design of the inquiry-based learning environment, we focused on the inquiry-based learning environment developed by the nine chemistry teachers who participated in PROFILES Cyprus 2012–13 as the final artifact. In this context, we analyzed the learning environment in order to investigate the extent to which students' views informed the final learning environment.

Finally, aiming to investigate the impact of the inquiry-driven learning environment on students' learning gains, data were collected through a test regarding students' content knowledge about energy drinks. The instrument was designed for the purpose of this study and was composed of five open-ended tasks.

In addition, student motivation data were collected through the MoLE-Questionnaire (Bolte, 2000) that was universally employed by PROFILES partners. The survey employed consisted of two different versions. The REAL version was administered before the teaching intervention and collected students' views of traditional chemistry lessons (Pre-test). The TODAY version was administered after the intervention and collected students' views about

the inquiry-based learning environment implemented (Post-test). Thus, the aim of the questionnaire was to examine student motivational gains, after their participation in the inquiry-based learning environment, by comparing the two versions. Both instruments were administered before and after the teaching intervention in three different 11th grade classrooms ($n=58$).

The final sample was composed of a total of 40 students, since the students, who had not completed either the pre- or the post-test for content and motivation, were excluded. As far as it concerns the analysis of the tests, the overall approach involved the investigation of the differences between pre- and post-test results on students' learning scores and motivation, employing the non-parametric Wilcoxon Signed-Rank Test for dependent samples.

Findings

Students' perspectives of an ideal chemistry learning environment

A visual representation of the results that emerged from the qualitative analysis of the two focus group sessions is presented in Figure 1. According to the main findings three organizing themes were identified and seemed to define an ideal learning environment for the 11th graders:

- (a) The teacher, in terms of his/her teaching approach,
- (b) The students in terms of their role within the learning process, and
- (c) The topic on which the learning environment is focused.

We next described these three organizing themes, focusing on the basic themes discussed and categorized under each organizing theme. The discussion includes indicative excerpts from the focus group sessions, translated from Greek into English.

Organizing Theme 1: The teacher

Students highlighted the role of the teacher,

explaining that a chemistry teacher could have a catalytic effect on the effectiveness of the learning environment. In this context, students highlighted that a chemistry teacher should integrate experiments, computers or audiovisual material in the lesson in order to shape an ideal learning environment for the students. Students also stated that a chemistry teacher should avoid or, at least, minimize the use of traditional teaching methods such as worksheets and textbooks or the use of lectures and demonstrations.

“I would prefer the lesson to be carried out with the use of interactive board and projectors. I would also prefer to participate in many more experiments (...).” (Student, FG1)

“I believe that the lesson would be much more interesting if we could employ computers. There was also some software that we could employ in order to carry out virtual experiments.” (Student, FG1)

“I think that it could be all about the medium (learning approach) that was employed. Instead of using the textbook, doing whatever is written in the textbook, reading the textbook, it would be much more interesting to watch a video [...] Anything else (would be much better than the

textbook)... It’s just so boring to use the textbook all the time and all that you had to do was to turn the page and read, turn the page and read (...).” (Student, FG1)

Organizing Theme 2: Students

Students also emphasized their role during a learning intervention, explaining that the way students were placed within the learning process could be decisive for the creation of an ideal learning environment. More specifically, students expressed that during an ideal chemistry lesson, the learning environment should be student-centered and thus, learners should have an active role. In addition, students expressed that it would be much better if they could have the opportunity to work in smaller groups as well as to collaborate.

“However, I believe that when you have the opportunity to do something on your own, then you have more chances to really understand it, instead of watching a demonstration by your teacher.” (Student, FG1)

“I think that we should work in smaller groups... Our teacher could not pay attention to all of us, as she could do if she would have to work for instance, with half of us (...).” (Student, FG1)

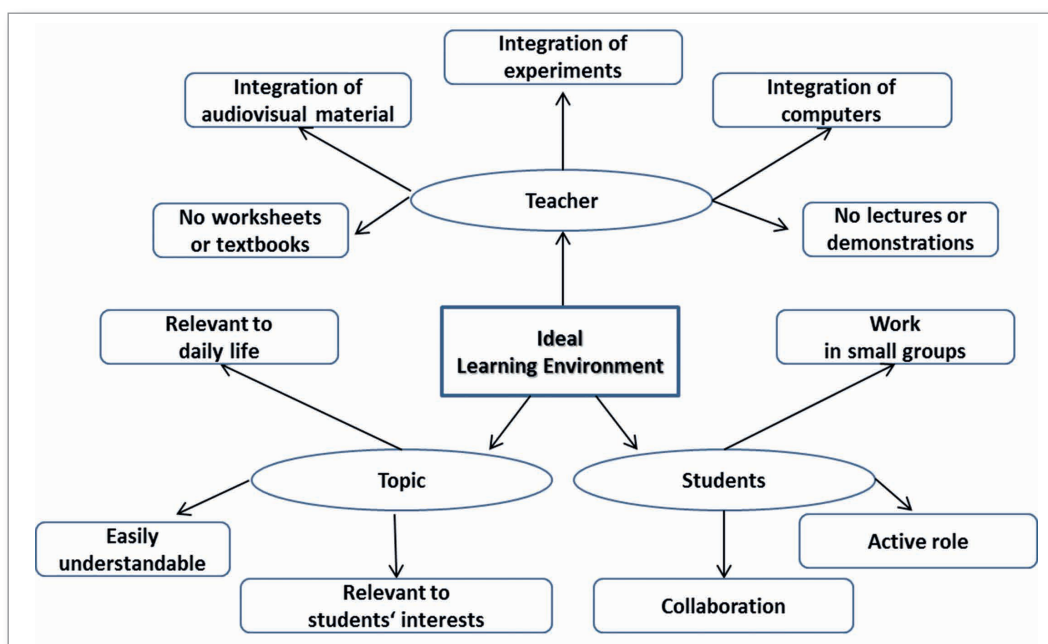


Figure 1. Representation of the results from the qualitative analysis of the two focus groups

“When students have the opportunity to collaborate they can better understand the experiments that are carried out as well as the lesson in general.” (Student, FG2)

“I would prefer to deal with topics from daily life that we could relate to from our everyday lives, that we could observe them and thus, we could investigate them much easier.” (Student, FG2)

Organizing Theme 3: Topic

Finally, the students highlighted that the topic of a module was a major variable that could result to an ideal learning environment. In this context, students indicated that it was of paramount importance for them to deal with topics that were relevant to their interests or with daily life, giving also plenty of suggestions and illustrations. At the same time, they stressed that the topic should be easily understood, explaining that they would prefer to avoid modules that give much emphasis on chemical equations and chemical symbols.

“I’ve heard that Cola zero causes multiple sclerosis when you drink it for a long period of time. I think that we need to be taught about such issues, in order to know what we consume as well as the impact on our health (...).” (Student, FG1)

“There are some chapters that we cannot really understand. Since we cannot understand, we are not really interested in (...).” (Student, FG2)

“Personally, I have a difficult time when I have to deal with chemical equations... There are so many chemical elements. I always forget their symbols and the numbers they get.” (Student, FG1)

Students' perspectives	Designing aspects
Topic: Relevance to students' interest	Focus on energy drinks consumption from teenagers
Topic: Relevance to daily life	Focus on energy drinks and their impact on humans
Topic: Easily understandable	Focus on energy drinks ingredients and their impact, avoiding chemical equations and symbols
Teacher: Integration of computers	Development of an inquiry-based learning environment on the STOCHASMOS web-based platform
Teacher: Integration of audiovisual material	Integration of audiovisual sources in the learning environment such as videos, photos and diagrams
Teacher: No textbooks	Use of authentic sources such as energy drinks labels, scientific or newspaper articles, scientific studies
Teacher: No lectures	Teachers as supporters, who scaffold students' investigation, when needed
Students: Active role	Students as active learners who are asked to collect data in order to take an evidence-based stance
Students: Collaborate in small groups	Students work in pairs
Students: Computer work	Students engage in computer-supported collaborative inquiry

Table 1. Students' view of an ideal learning environment as these were reflected through the learning environment developed

	MEAN VALUE		STANDARD DEVIATION		Z	P
	PRE	POST	PRE	POST		
TOTAL	3,44	5,34	1,24	1,48	-5,31	.000*
What is an energy drink?	0,60	0,84	0,26	0,36	-3,51	.000*
What are its main ingredients?	0,76	1,48	0,54	0,55	-4,91	.015*
What is its impact on human?	0,94	1,30	0,51	0,56	-2,43	.000*
What is its impact when mixed with alcohol?	0,74	0,95	0,36	0,53	-2,07	.039*
With what criteria would you buy an energy drink?	0,40	0,78	0,67	0,58	-2,79	.005*

*Statistically significant difference

Table 2. Descriptive statistics and Wilcoxon Signed-Rank Tests for comparing pre- and post-tests of conceptual understanding

Students’ views informing the design of the inquiry-based learning environment

Focusing on the design of the inquiry-based learning environment, the nine chemistry teachers, who participated in PROFILES 2012–13, made an effort to develop a learning environment which was informed by the students’ views, as these were elicited through the focus groups. An overview of the extent to which the students’ views informed the design is presented in Table 1.

In this context, aiming to respond to students’ views regarding an ideal learning environment, the teaching intervention designed by the PROFILES chemistry teachers took the form of an inquiry-based learning environment, which was hosted on the STOCHASMOS web-based platform (Kyza & Constantinou, 2007). The intervention was included four 40-minute lessons. More specifically, the learning environment integrated the inquiry-based philosophy since:

- It was based on an authentic scenario related to students’ interests: Students were asked to investigate whether the fainting of a teenager could be attributed to the consumption of energy drinks;
- It actively involved students with technology-enhanced inquiry-based investigations: students were asked to gather information regarding the ingredients of energy drinks as well as regarding their impact on humans through a variety of authentic sources (e.g.

- newspaper articles, scientific studies) and audiovisual material (e.g. video clips, photos);
- It engaged students in a decision-making process asking them to take an evidence-based stance regarding the consumption of energy drinks.

In addition, taking into account that the inquiry-based learning environment designed was implemented on the STOCHASMOS web-based platform (www.stochasmos.org), this not only allowed the integration of technology, but shaped and defined the roles of both teachers and students. More specifically, STOCHASMOS enabled students to assume an active role as well as to be involved in a collaborative investigation, while at the same provided computer-based scaffolding to support students’ reflective inquiry (Kyza & Edelson, 2005). At the same time, STOCHASMOS enabled teachers to assume a supportive role, in terms of scaffolding their students by providing individualized feedback when needed, through their interactions with the student groups.

Students’ learning gains: Conceptual understanding

As indicated in Table 2, the analysis of students’ conceptual understanding, as measured by the pre-post tests, revealed statistically significant increases after the inquiry-based intervention. According to the findings, there was a significant difference in the scores of the students before the teaching intervention ($M=3.44$, $SD=1.24$) and in

their scores after the teaching intervention ($M=5.34$, $SD=1.48$), $Z=-5.31$ - $p<.001$. More specifically, this comparison revealed that students increased their knowledge regarding what is an energy drink, what are its main ingredients, what is its impact on humans, what is its impact when mixed with alcohol, while at the same time students acquired more informed criteria regarding the choice of an energy drink (e.g. ingredients, quantity, impact vs. price, taste, etc.).

Students' learning gains: Motivation

As Table 3 shows, the analysis of students' motivation, as measured by the pre-post MOLE test, revealed a statistically significant increase after the inquiry-based intervention. According to the findings, it seems that there was a significant difference in the motivation of the students as shown by the comparison of their motivation before the teaching intervention ($M=4.51$, $SD=1.08$) and after the teaching intervention ($M=5.11$, $SD=1.18$); $Z=-5.49$ - $p<.001$). More specifically, this comparison revealed that students understood and enjoyed the inquiry-based lesson more, felt that they had more time to think before answering a question, had more opportunities to make suggestions and questions, collaborated to a greater extent with other students and were taught about issues that were more relevant to them.

Discussion

At a time of continued dissatisfaction with the state of science education in many parts of the world, science education stakeholders are investigating ways to promote students' appreciation of the nature of science, improve the quality of learning, and establish science learning as a meaningful and motivating activity. In this context students' disengagement with learning in science is being attributed, in many cases, to the fact that students' perspectives regarding teaching and learning in science are often neglected (Fensham, 1998). Therefore, Logan and Skamp (2008) suggest that "the importance of listening to and heeding the students' voice may be an even more critical concern in addressing the decline in students' attitudes and interest in science" (p. 501).

The present study was based on a participatory design model, according to which in-service chemistry teachers, who participated in PROFILES Cyprus 2012–13, designed an inquiry-based module informed by their students' views regarding an ideal learning environment. This process, as it has been presented, consisted of three separate parts: (a) the collection and analysis of students' perspectives, (b) the development of the inquiry-based learning environment based on students' views and (c) the implementation and evaluation of the learning environment.

	MEAN VALUE		STANDARD DEVIATION		Z	p
	REAL	TODAY	REAL	TODAY		
TOTAL	4.51	5.11	1.08	1.18	-5.489	.000*
Comprehensibility	4.85	5.38	1.35	1.43	-3.533	.000*
Opportunities	4.37	4.73	1.71	1.62	-2.267	.008*
Willingness	5.07	5.91	1.29	1.59	-1.545	.122
Cooperation	4.11	5.06	1.20	1.35	-4.102	.000*
Satisfaction	3.91	5.47	1.58	1.30	-5.135	.000*
Relevance	4.54	5.10	1.45	1.65	-2.679	.007*

*Statistically significant difference

Table 3. Descriptive statistics and Wilcoxon Signed-Rank Tests for comparing pre- and post-tests of students' motivation

Our findings provide empirical evidence to support the argument that the development of a learning environment, which takes students’ perspectives into account, can result to substantial learning gains for students in terms of increased conceptual understanding and motivation. Such findings are aligned with the participatory design approach according to which effective involvement of users in the design phase yields improved adjustment of the design to address users’ needs as well as higher levels of acceptance of the final design by the users (Damodaran, 1996). Despite the fact that participatory design is fairly new in school contexts, the present study has indicated that, if we wish to promote learning and teaching in science, we need to exploit this venue as a more sustainable approach for the design of more effective learning environments in science education.

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