This is a previous version of the article published in Learning Environments Research. 2016, 19(1): 87-106. doi:10.1007/s10984-015-9201-6

Student perceptions of cell biology laboratory learning environment in four undergraduate science courses in Spain

LERI-D-14-00006R3

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Submitted 24 February 2014 - Accepted 24 February 2015

Abstract

Cell biology is an academic discipline that organises and coordinates the learning of the structure, function and molecular composition of cells in some undergraduate biomedical programs. Besides course content and teaching methodologies, the laboratory environment is considered a key element in the teaching of and learning of cell biology. The aim of this study was to determine students' opinions about the quality of the teaching and learning environment in cell biology laboratory practice. For this study, we used a short form of the Science Laboratory Environment Inventory (SLEI), which we adapted and translated into Spanish. The questionnaire, administered to students enrolled in four undergraduate programs, consisted of 24 questions divided into four scales: integration of content, clarity of laboratory rules, cohesion between students and teachers, and quality of laboratory infrastructures and materials. The results suggested that (1) students positively assessed the learning environment provided for cell biology practice, (2) the short Spanish form of the SLEI was a valid, reliable instrument for evaluating student satisfaction, laboratory activities, the degree of cooperation between students and teachers, and theoretical and practical organisation of content and (3) the questionnaire detected differential perceptions of the learning environment based on gender and the program studied.

Keywords: cell biology practice, gender differences, Science Laboratory Environment Inventory (SLEI), learning environment, undergraduate education

Introduction

What is cell biology?

The academic discipline of cell biology can be defined as the study of the structure, function and molecular composition of cells. It is a core subject for students of nursing, medicine, dentistry, pharmacy, nutrition, biology, chiropody, physiotherapy and veterinary medicine (ANECA 2012). Learning cell biology presents three major challenges: (1) the abundant and increasing amount of information (Wright and Boggs 2002), (2) frequent changes in associated models and theories (Howard and Miskowski 2005) and (3) the need for practice in order to understand content and acquire skills.

Science laboratories

Laboratory practice has always been controversial. In the 1970s and early 1980s of the last century, some authors questioned the role and effectiveness of practice, arguing that the benefits were less evident than what was claimed (Bates 1978; Saunders and Dickinson 1979). Subsequent studies, however, demonstrated the opposite (Lightburn 2002; Hofstein and Lunetta 2004). Traditionally, in Spain, laboratory practice follows a cookbook approach. In other words, the laboratory experience begins with the teacher's explanation, then there are student activities that are directed step by step by a script, and finally come questions that are answered (Leonard 1991).

As in the majority of Spanish colleges, our laboratory practice is usually organised as follows. The instructor starts by introducing the general topic and presenting the theoretical aspects of procedures. After that, students receive the laboratory protocols and all materials needed for conducting the procedures indicated in the practice syllabus. In most cases, the students are organised into groups of two to four people in order to collaborate in their work. The instructor then supervises the students' work and corrects any potential mistakes, guiding them to achieve correct or expected results. In the last stage of the class, or afterwards as homework, students answer a series of questions related to the results obtained and create a portfolio explaining how their practice developed.

However, the implementation of the European Higher Education Area, which entered into force with the Budapest-Vienna Declaration of March 2010, has led many people to reconsider the role of applied knowledge in the new course syllabuses (Raposo and Zabalza 2011). Despite its importance, no satisfactory method has yet been found for integrating laboratory practice into science teaching (Martínez-Torregrosa et al. 2012). Hence, there is a need to evaluate this practice through students' perceptions in order to identify how resources are used, how learning can be enhanced, and how teaching can be evaluated in the laboratory (Hofstein and Lunetta 2004).

Despite this controversy, from the 1960s until now, new strategies have been made available for the integration of laboratory practice in science education. Some of them (e.g., multi-week research) promote research-based activities and interest in science (Hunter et al. 2007; Russell et al. 2007). Others (e.g., inquiry-based laboratories*)* are based on exercises organised around questions and problems (Allen and Tanner 2003; Siritunga et al. 2011; Volkmann and Abell 2003) to develop critical thinking (Moon 2008), analytical thinking (Kitchen et al. 2003) and data interpretation (DiCarlo 2006). Still other approaches are concerned with the standards to be adhered to in the laboratory (Tanner and Allen 2002), collaborative learning (Tanner et al. 2003; Wright and Boggs 2002) and experiential learning (Cantor 1995; DebBurman 2002).

Learning environment

It is important to learn how students perceive the learning environment in their laboratory practice. Because the term 'learning environment' can be understood in many ways, numerous definitions and measurement instruments are available (Vizcaya-Moreno et al. 2004a; Vizcaya-

Moreno et al. 2004b). ‘Learning environment’ is more commonly used to refer to the social, conceptual and psychological environment than to the spatial or physical learning environment (Cleveland 2009). However, the learning environment can encompass everything from the physical context and its emotional or psychological conditions to socio-cultural influences in teaching (Hiemstra 1991). Increasing numbers of both teachers and design experts are becoming aware of the important role that physical space plays in educational configurations (Cleveland and Fisher 2014). On the other hand, Knowles (1990) called this concept the ‘learning climate,’ highlighting its human, physical, interpersonal, and organisational characteristics. In this way, well-being in the laboratory is a crucial aspect in the development of students’ affectivity and attitudes towards their teachers, classmates, courses and the general educational system (Zedan 2010). In this sense, the learning environment is designed for student learning, and it is a critical factor in educational achievement (Baek and Choi 2002). Based on the above thinking, Fraser (1998) subsequently delineated the quantitative and descriptive aspects of what he called ‘science learning environments.’

In science courses in general and cell biology courses in particular, laboratories are different environments from conventional classrooms. Laboratories play an important role in scientific disciplines because activities are designed to be performed in them. Suitable physical facilities and psychosocial aspects increase students’ social and problem-solving skills, positive attitudes towards science, learning and intellectual abilities, and understanding of scientific concepts (Arzi 1998). Satisfaction after using a product or service can be considered an important indicator of throughput (Anderson et al. 1994). In education, both teachers’ and students’ satisfaction, as well as their teaching and learning styles, can be affected by the quality of their classroom facilities (Guolla 1999). Their satisfaction can modify their attitudes (Henderson et al. 2000, Hofstein and Lunetta 2003) and therefore improve their performance.

To sum up, activities in classrooms can develop in different ways, depending on how groups feel and experience their particular environments, often referred to as the climate, culture, ambience or atmosphere in which teaching and learning take place. Learning environments are conceived as ecosystems, and any action in the classroom can produce changes in contextual variables, which in turn can affect the learning environment as a whole (Ahmad et al. 2013; Fraser 1986).

Learning environment instruments

Research on learning environments commenced in the United States with the Learning Environment Inventory (Walberg and Anderson 1968) and the Classroom Environment Scale (Moos and Trickett 1974). The availability of these tools in other countries gave rise to new instruments, such as the Questionnaire on Teacher Interaction in Holland (Fraser and Walberg 2005) and the Individualised Classroom Environment Questionnaire in Australia (Fraser 1990). However, it was in Australia where the need to assess the learning environment in science laboratories (Fraser et al. 1993) was the most seriously addressed, leading to the development and validation of the Science Laboratory Environment Inventory or SLEI (Fraser et al. 1995).

The SLEI was field-tested in six countries (Fraser et al.1992; Fraser et al. 1993; Fraser and McRobbie 1995; McRobbie and Fraser 1993). It has been validated and through various studies conducted in Australia (Fisher et al. 1998; Fraser et al. 1995; Henderson et al. 2000), Singapore (Quek et al. 2002; Waldrip and Wong 1996; Wong and Fraser 1995), Papua New Guinea (Waldrip and Wong 1996) and South Korea (Fraser and Lee 2009).

Because of the high sensitivity of the SLEI, students' perceptions of laboratories can be compared in different situations and according to different variables, such as: (1) gender (Fraser et al. 1995; Quek et al. 2002); (2) type of teaching strategies employed (open vs. closed) (Hofstein et al. 2001); (3) subjects studied (chemistry, physics, biology and cell biology) (Fisher et al. 1997; Fraser and Lee 2009; Hofstein et al. 1996; McEwen et al. 2009); (4) languages into which it has been translated such as Hebrew (Hofstein et al. 1996) and Korean (Fraser and Lee 2009); and (5) type of laboratory practice conducted (Hofstein et al. 1996; McEwen et al. 2009).

Rationale

In order to improve the quality and integration of cell biology laboratory practice, the Biotechnology Education Network allowed us to develop an educational project, with the approval of the Institute of Education Sciences at our university. In this study, we evaluated first-year university students' perceptions of psychosocial aspects in their cell biology laboratory learning environment in the College of Experimental Sciences and the College of Health Sciences. Our aim was to evaluate and compare students' perceptions of this learning environment by using different teaching strategies, taking into account students' gender and their enrolment in different colleges and programs. In addition, this was a pilot study aimed at refining a method that would allow us to use the SLEI on a large scale in several Spanish and Latin-American universities. In order to achieve this goal, we used a short form of the SLEI (Lightburn 2002), which we adapted and translated into Spanish.

Materials and methods

Participants

In the academic year 2010–2011, we surveyed 174 students in their first year of the undergraduate biology and marine sciences programs in the College of Experimental Sciences and nursing and human nutrition and dietetics programs in the College of Health Sciences. All had received theoretical and practical training in cell biology in their cell biology (biology and marine sciences) programs and biology (nursing and human nutrition and dietetics) programs. Convenience non-probability sampling was employed to select the sample.

Instrument

We used a short form (Lightburn 2002) of the SLEI containing 24 questions grouped into four subscales with six questions each, which we translated into Spanish, following the recommendations of Newmark (1998), Cha et al. (2007) and the Census Bureau Guideline for the Translation of Data Collection Instruments (Pan and Puente 2005). Henceforth, we refer to this translation as the Spanish Abbreviated SLEI (SASLEI).

Study procedure

In the biology and marine sciences programs, the questionnaires were completed in the classroom during class hours. In the nursing and human nutrition and dietetics programs, the questionnaires were administered through the Virtual Campus. All questionnaires were anonymous, and informed consent was obtained.

The questions were answered by marking one letter (A, ‘almost never’; B, ‘seldom’; C, ‘sometimes’; D, ‘often’; and E, ‘very often’) corresponding to a score from 1 to 5. Omitted or invalid responses were scored as 3. In order not to bias the students’ responses, the negative or positive sense of nine questions on the questionnaire was randomly modified. See Lightburn (2002) for a detailed overview of this procedure.

To verify the validity of the SASLEI, we conducted a principal components factor analysis with varimax rotation, using the questions as variables. The number of factors to be extracted was set at four, corresponding to the number of factors in the short form of the SLEI. Questions were included in each factor when $r \geq 0.40$ for that factor and $r \leq 0.30$ for the others (Lightburn 2002).

In addition, we performed a cluster analysis on these questions. The number of clusters to be extracted was also established as four.

The internal consistency of the SASLEI was calculated using Cronbach's (1951) alpha coefficient. The discriminant validity of the scales was determined using the mean value of interscale correlations.

Univariate analyses (one- and two-way analyses of variance and Pearson correlation coefficients) and multivariate analyses (factor and cluster analysis) were performed using the software packages StatView©, JMP8© and SPSS®. Statistical significance was established as $p \leq 0.05$.

Results

Characteristics of the sample

The 174 students surveyed (Table 1) were distributed evenly between the two colleges. Of these, 48.3% belonged to the College of Experimental Sciences and 51.7% to the College of Health Sciences. Distribution was also homogeneous within the College of Experimental Sciences: 47.7% were enrolled in the marine sciences program and 52.3% in biology. In the College of Health Sciences, however, the distribution was less balanced, with 71.1% of students enrolled in the nursing program and 28.9% in human nutrition and dietetics.

In the sample, 70.7% were female, and male participation was lower in both colleges, especially the College of Health Sciences. Whereas 56% of the participants from the College of Experimental Sciences were female, in the College of Health Sciences, they accounted for 84.5% of the students surveyed. In all the courses, female participation was higher than that of males, especially in nursing (81.3%) and human nutrition and dietetics (92.3%). In biology and marine sciences, the difference between male and female participation was less marked. In marine sciences, females represented 60% of participants while, in biology, they accounted for 52.3%.

Validity and reliability of the questionnaire

In order to verify the validity of the SASLEI questionnaire, we conducted a principal components factor analysis with varimax rotation, using the questions as variables. However, we performed a preliminary test to find out how many factors were determined by the application. Questions were included in each factor when $r \geq 0.40$ for that factor and $r \leq 0.30$ for the others (Lightburn 2002). In addition, we performed a cluster analysis with these questions. The number of clusters to be extracted was also established as four.

Two sets of FA were performed using the answers to the SASLEI's 24 questions (Appendix A). In the first factor analysis (FA1), the answers not filled out were scored as 3. In the second factor analysis (FA2), the unanswered questions were left blank. Both analyses grouped the SASLEI's 24 questions into 10 factors (Table 2) and showed quite similar patterns. Thus, the first four factors matched closely and accounted for 50% of all questions. The remaining factors, although with some overlap between both analyses, contained the rest of the questions from the SASLEI in a diffuse distribution.

Moreover, to determine an adequate number of factors in this study, we used two methods: Cattell scree test plots and the comprehensibility method. The latter is a relatively subjective method that involves retaining those factors whose meaning is comprehensible to the researcher. In this study, four was a more adequate number of factors, coinciding with the number of factors (Lightburn 2002).

After establishing four as the ideal number of factors, we proceeded to repeat the two sets of factor analyses using the same data, but with four as the number of factors to be obtained. In the first factor analysis, the questions not answered were again scored as 3. In the second factor analysis, the unanswered questions were also left blank. Both analyses grouped the SASLEI's 24 questions into four factors (Table 3), similar to the distribution observed in the SASLEI. Following an iterative process to eliminate questions with an unsatisfactory factor loading, the number of questions in the SASLEI was reduced to 19 (Table 3).

Six of the 19 questions were grouped into the first factor (questions 1, 5, 9, 13, 17 and 21), with factor loadings of $r \geq 0.7$ on their own scale and $r \leq 0.3$ on the others. These six questions were the same as those included in the 'integration' scale in the SASLEI. Five questions were obtained for the second factor (questions 2, 6, 7, 10 and 14), with factor loadings of $r \geq 0.5$ on their own scale and $r \leq 0.3$ on the others. These coincided with five (83.36%) of the six questions grouped together in the 'rules' scale used in the SASLEI. The third factor contained four questions (questions 8, 12, 16 and 20), with factor loadings of $r \geq 0.4$ in their own scale and $r \leq 0.3$ in the others. These coincided with four (66.6%) of the six questions grouped in the 'materials' scale in the SASLEI. Finally, four (66.6%) of the six questions in the 'cohesion' scale were grouped into the fourth factor (questions 3, 11, 19 and 23), with factor loadings of $r \geq 0.5$ for this factor and $r \leq 0.3$ for the other three. In summary, of the 24 questions from the original questionnaire, 19 (80%) coincided with a distribution into four scales of the SASLEI.

The cluster analysis grouped the 24 questions into four clusters (Figure 1). In cluster A, six questions were grouped into the 'integration' scale. Seven questions were grouped into cluster B, of which four (66.6%) agreed with the four in the 'rules' scale (questions 2, 14, 18 and 22) used in the SASLEI. The five questions grouped into cluster C, which coincided with the five questions (83.3%) in the 'materials' scale (questions 4, 12, 16, 20 and 24). Lastly, cluster D grouped six questions, of which four (66.6%) agreed with four in the 'cohesion' scale (questions 3, 11, 15 and 19) used in the SASLEI. In summary, of the SASLEI's 24 questions, 19 (80%) showed a high correspondence with the four factors in the FA and the four scales in the SASLEI. Similarly, the distribution of 20 (83.3%) of the 24 cluster analysis questions (Figure 1) showed a high correspondence with the four scales in the SASLEI.

Regarding the questionnaire's reliability (Table 4), we obtained the following data. The alpha value for the total student sample was 0.83. For the scales 'integration' and 'rules,' the reliability values were 0.91 and 0.72, respectively. A reliability of 0.6 was found for the 'cohesion' and 'materials scales.' The four SASLEI scales had alpha values of between 0.62 and 0.88 in the biology and nursing programs. However, in marine sciences and human nutrition and dietetics, some of the scales obtained an alpha reliability of ≤ 0.60.

The discriminant validity analysis showed a high correlation between 'integration' and 'rules' ($r = 0.87$) and 'materials' and 'cohesion' ($r = 0.94$). For the remaining pairs, the correlation was low between 'integration' and 'materials' ($r = -0.38$) and 'integration' and 'cohesion' ($r = 0.29$), and extremely low between 'rules' and 'cohesion' ($r = 0.14$) and non-existent between 'rules' and 'materials' ($r = 0.03$). These data reduced the four scales to two blocks: block 1 ('integration' and 'rules') and block 2 ('cohesion' and 'materials').

When the scores for the four programs were correlated, we observed a trend whereby courses in the same college were clustered together and distanced from courses in the other colleges. Thus, the correlation was high between biology and marine sciences ($r = 0.95$) and between nursing and nutrition ($r = 0.78$), and low between nursing and biology ($r = 0.49$) and nursing and marine sciences ($r = 0.28$).

Evaluation of the cell biology laboratory environment

The SASLEI produced mean scores close to 4, but the scores were significantly higher for the College of Health Sciences than for the College of Experimental Sciences (Figure 2 and Table 5). The lowest overall score was for Integration for both samples (Figure 2 and Table 5). Scores were significantly different between all four programs' courses, except between nursing and nutrition (Figure 2 and Table 6).

The scale that generated the highest scores was 'cohesion,' with values of ≥ 4 for both colleges (Figure 2 and Table 5) and for all four programs. However, no significant differences were observed between them (Figure 2 and Table 6). The College of Health Sciences also had significantly higher scores for the scale 'rules' than the College of Experimental Sciences (Figure 2 and Table 5), as did the nursing program when compared with the other programs (Figure 2 and Table 6).

The third place was occupied by the scale 'materials,' with a significantly higher score for the College of Health Sciences than for the College of Experimental Sciences (Figure 2 and Table 5). However, no significant differences were observed between the four programs' courses (Figure 2 and Table 6).

In summary, the scale with the highest scores was 'cohesion,' followed by 'rules.' 'Integration' had the lowest score, especially for the two programs in the College of Experimental Sciences. The scale 'materials' had a consistently high score in both colleges and across all courses.

Females had a significantly higher mean score than males (Figure 2 and Table 7), both globally and within the scales of 'integration' and 'rules.' Similarly, in the College of Experimental Sciences, females had significantly higher scores for the scales 'rules' and 'cohesion.' No significant differences were observed for the remaining scales, either within the total sample or within the colleges (Figure 2 and Table 7). However, in the biology program, females had significantly higher scores for all scales (Figure 2 and Table 7).

Discussion

In this study, we used a short form (Lightburn 2002) of the SLEI (Fraser et al. 1995; Fraser and McRobbie 1995) that was adapted and translated into Spanish and given the acronym SASLEI. The short form consists of 24 questions instead of the 35 contained in the SLEI, distributed across four scales instead of five and with six questions in each scale rather than the seven contained in the SLEI.

Like the SLEI, the SASLEI exhibited satisfactory factorial validity and reliability and had the capacity to detect differences between programs' courses. Factor and cluster analysis grouped the questions into four scales for the SASLEI. Following factor analysis, the number of questions in both the SASLEI and the Korean version (Fraser and Lee 2009) of the SLEI was reduced from 24 to 19 (21%), in the first, and from 35 to 23 (34%), in the second. Factor loadings for the questions in the SASLEI were higher (between 0.43 and 0.86) than those obtained in the Korean version (between 0.41 and 0.78). In the SASLEI, 50% of the variance was represented by the four scales (Table 3). In the Korean translation of the SLEI, 50% of the variance was represented by five scales. In the SASLEI, 'integration' and 'rules' were the scales that best explained the variance, while the 'cohesion' and 'integration' scales were better in the SLEI questionnaire.

The SASLEI exhibited high (0.83) internal consistency (Table 4), with Cronbach's alpha coefficient ranging between 0.60 and 0.91 for different scales, which are similar to those for the Korean version (between 0.62 and 0.72). These values are considered acceptable for this type of research (Chan 1999; Nunnally 1967). The mean alpha coefficient indices for the four programs' courses studied were also acceptable, ranging between 0.68 and 0.86 (Table 4). More specifically, reliability values were acceptable for the four scales in biology and nursing, for three scales in nutrition (for all except 'rules'), and for two scales ('integration' and 'rules') in marine sciences. The latter result indicates the need for larger samples from some programs' courses.

The SASLEI scales were grouped into two blocks: one consisting of 'teaching organisation' formed by the scales 'integration' and 'rules'; and another consisting of 'laboratory conditions', which contained the scales 'cohesion' and 'materials.' This could have been because of a lack of discrimination between the scales in each block or a convergent discrimination that would enable simplification of the questionnaire.

In the SASLEI (Table 7), as in the SLEI (Fraser et al. 1995; Quek et al. 2002), females had higher mean score than males, especially for the scales ‘integration’ and ‘rules,’ for the total sample, and ‘rules’ and ‘cohesion,’ for the College of Experimental Science. Among the four programs, the higher score for females was only statistically significant for biology. It would appear that female students of experimental scientific disciplines, such as chemistry and biology, most consistently give higher scores, as in previous studies (Fraser et al. 1995; Goh 2014; Quek et al. 2002).

The scale ‘integration,’ which had the highest scores in other studies (Fraser and Lee 2009), had a surprisingly low score among students studying in the College of Experimental Sciences programs, in contrast with the higher scores for students of the College of Health Sciences (Tables 5 and 6). These data are interesting because ‘integration’ is a predictor of student attitudes (Fraser and Lee 2009). The score for the scale ‘rules’ was similar to that in other studies (Fraser and Lee 2009) and was significantly higher in the College of Health Sciences than in the College of Experimental Sciences. These differences between the two colleges could be due to the characteristics of the courses. Thus, in some studies (Fisher et al.1997), biology scores were lower than for chemistry or physics for the scale ‘integration,’ and also were the lowest in the SLEI study conducted by McEwen et al. (2009).

No significant differences between the programs’ courses were observed for the scale ‘cohesion’ and ‘materials’ (Table 5). These scales’ close relationship has also been observed in studies by Lightburn and Fraser (2007), who reported that the aspects categorised within biology laboratory practice as ‘materials’ had higher scores than those falling under ‘cohesion.’

In conclusion, we have learned that, when dealing with a common subject (cell biology), similar content and the same learning environment, the SASLEI is a good discriminator. As in other studies, students positively assessed the learning environments of their laboratory practice.

Females had higher scores than males in the College of Health Sciences. The SASLEI is a valid, reliable instrument for evaluating the degree of student satisfaction, level of collaboration between classmates and teachers, laboratory resources and activities in cell biology studies, and organisation of cell biology theory and practical content.

Acknowledgments

Thanks to Prof. Kate Wright, Associate Deputy Vice-Chancellor, Curtin University for granting us permission to use and translate the modified version of the Science Laboratory Environment Inventory (SLEI) employed in the thesis of by Lightburn, M. E. (2002). *Evaluation of anthropometry activities for high school science: Student outcomes and classroom environment*. Unpublished PhD thesis, Curtin University, Western Australia. http://espace.library.curtin.edu.au:80/R?func=dbin-jump-full&local_base=gen01-era02&object_id=14071 (accessed 14 July 2012).

This work was supported by the Teaching Research Program "Networks" from Institute of Education Sciences (ICE) at University of Alicante, Biotechnology Network (Reference 2885).

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Appendix A Adaptation and translation into Spanish of the modified version of Science Laboratory Environment Inventory (SLEI) (Fraser et al. 1993, 1995) realised by Lightburn (2002)

Preguntas	(A) Casi nunca	(B) Rara vez	(C) Algunas veces	(D) A menudo	(E) Muy a menudo
1. Mi trabajo habitual en la clase teórica está integrado con las actividades prácticas de laboratorio.	A	B	C	D	E
2. En mis prácticas de laboratorio hay normas claras para guiar mis actividades	A	B	C	D	E
3. Me llevo bien con los compañeros en las prácticas de laboratorio.	A	B	C	D	E
4. Creo que hay demasiada gente en el laboratorio cuando realizo las prácticas.	A	B	C	D	E
5. Utilizo los contenidos teóricos de mis clases en las prácticas de laboratorio.	A	B	C	D	E
6. Debo cumplir ciertas reglas en el laboratorio.	A	B	C	D	E
7. El personal del laboratorio de prácticas me ayuda.	A	B	C	D	E
8. Los equipos y materiales que necesito para las prácticas de laboratorio son fácilmente accesibles.	A	B	C	D	E
9. Los temas tratados en las clases teóricas son muy diferentes de los tratados en el laboratorio de prácticas.	A	B	C	D	E
10. Reconozco que en el laboratorio hay una forma segura de hacer las cosas.	A	B	C	D	E
11. Conozco bien a los compañeros de las prácticas de laboratorio.	A	B	C	D	E
12. Me avergüenzo del aspecto del laboratorio de prácticas.	A	B	C	D	E
13. Lo que hago en las prácticas de laboratorio me ayuda a entender las clases teóricas.	A	B	C	D	E
14. El profesor me explica las precauciones de seguridad antes de comenzar cada práctica de laboratorio.	A	B	C	D	E
15. Puedo contar con mis compañeros si necesito ayuda durante las prácticas de laboratorio.	A	B	C	D	E
16. El equipamiento que utilizo en el laboratorio no funciona correctamente.	A	B	C	D	E
17. Lo que hago en la clase teórica no se relaciona con mi actividad en las prácticas de laboratorio.	A	B	C	D	E
18. Hay pocas reglas establecidas que deba seguir en el laboratorio durante las prácticas.	A	B	C	D	E
19. Trabajo de forma cooperativa en las prácticas de laboratorio.	A	B	C	D	E
20. El laboratorio de prácticas me parece un lugar atractivo para trabajar en él.	A	B	C	D	E
21. Mi trabajo en el laboratorio y el de la clase teórica no guardan relación.	A	B	C	D	E
22. Mis prácticas de laboratorio son más bien informales y hay pocas reglas establecidas.	A	B	C	D	E
23. Tengo pocas oportunidades para conocer a otros estudiantes en las clases prácticas de laboratorio.	A	B	C	D	E
24. Mi laboratorio de prácticas tiene suficiente espacio para trabajar individualmente o en grupo.	A	B	C	D	E

List of figures

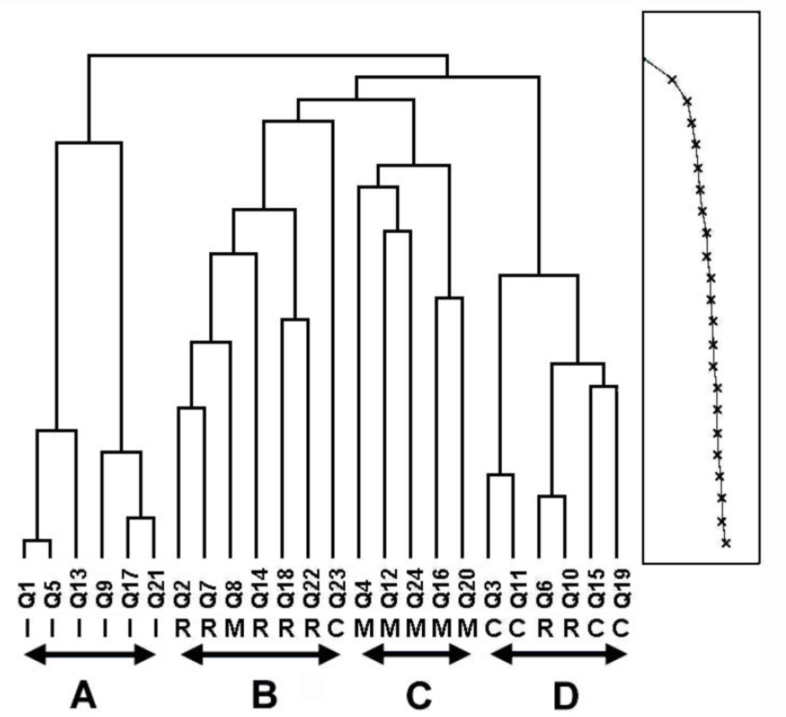
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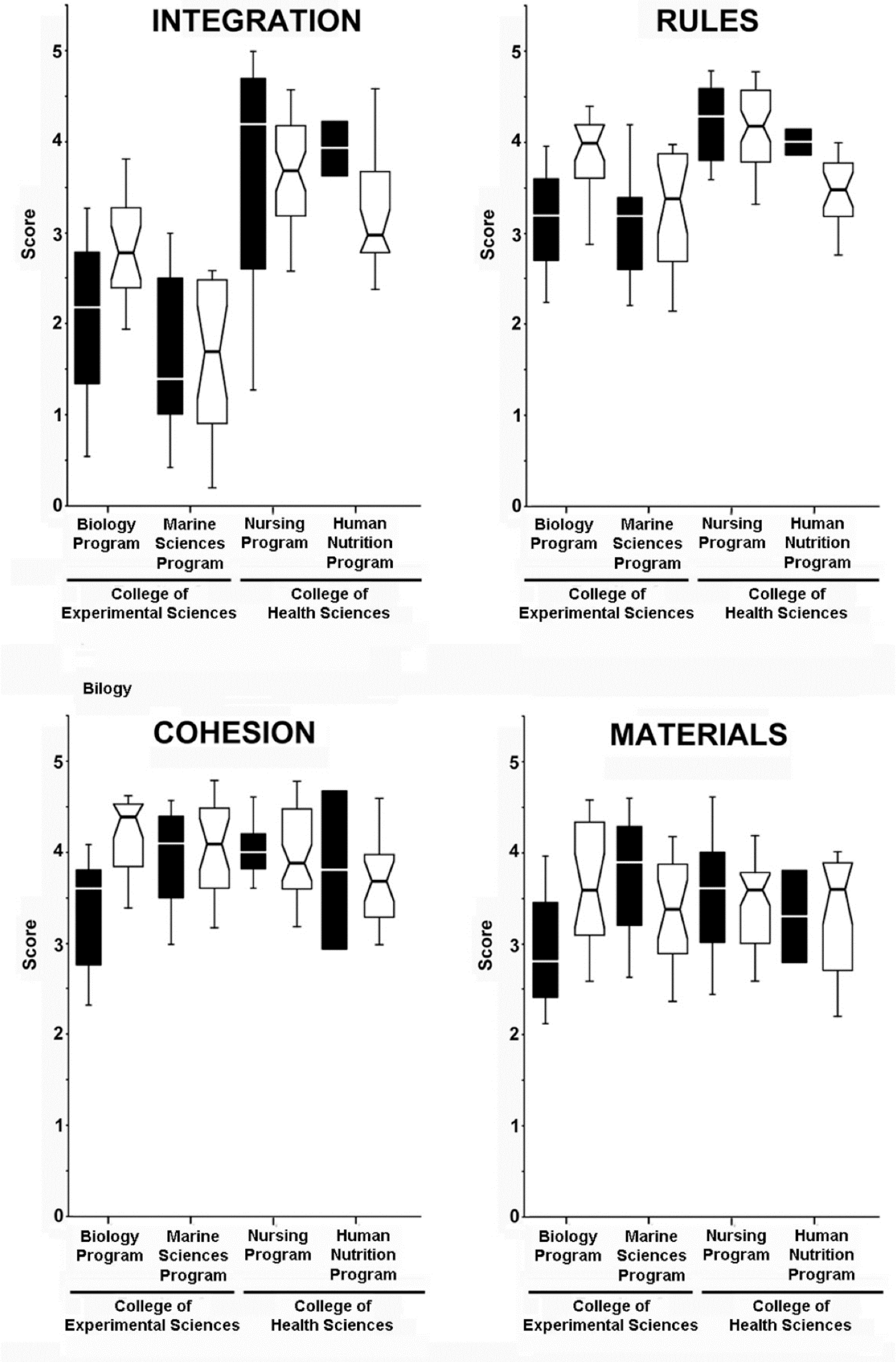
Fig. 1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Biology Program
Marine Sciences Program
Nursing Program
Human Nutrition Program
College of Experimental Sciences
College of Health Sciences
Bilogy

Fig. 2

Table 1 Number (N) and percentage (%) of students enrolled and surveyed and distribution by college, program and gender

Students from the College of Experimental Sciences						
Gender	Marine Science		Biology		Marine Science and Biology	
	Enrolled N (%)	Respondents N (%)	Enrolled N (%)	Respondents N (%)	Enrolled N (%)	Respondents N (%)
Females	30 (49.2)	24 (60.0)	38 (54.3)	23 (52.3)	68 (52.0)	47 (56.0)
Males	31 (50.8)	16 (40.0)	32 (54.3)	21 (47.3)	63 (48.0)	37 (44.0)
Total	61 (100)	40 (100)	70 (100)	44 (52.3)	131 (100)	84 (100)

Students from the College of Health Sciences						
Gender	Nursing		Human Nutrition and Dietetics		Nursing and Human Nutrition and Dietetics	
	Enrolled N (%)	Enrolled N (%)	Enrolled N (%)	Enrolled N (%)	Enrolled N (%)	Enrolled N (%)
Females	138 (76.0)	52 (81.3)	66 (81.5)	24 (92.3)	204 (77.6)	76 (84.4)
Males	44 (24.0)	12 (18.7)	15 (18.5)	2 (7.3)	59 (22.4)	14 (15.6)
Total	182 (100)	64 (100)	81 (100)	26 (100)	263 (100)	90 (100)

Table 2 Factor analysis results for the SASLEI

Factor analysis 1: The answers not filled out were scored as 3. The factors number were determined by the application

Characteristic	Factor									
	Integration	Rules	Materials	Cohesion	Rules and Cohesion	Materials	Rules	Rules	Materials	Cohesion
Questions No.	1, 5, 9, 13 17, 21	2, 14	12, 16	3, 11	10, 19	4, 24	22	6	8	23
Eigenvalues	6.05	3.24	1.54	1.36	1.23	1.04	0.98	0.93	0.81	0.77
Explained variance (%)	25.24	13.49	6.40	5.65	5.10	4.33	4.07	3.90	3.39	3.20

Total variance: 74.75%
Factor loadings smaller than 0.4 omitted
The sample consisted of 174 students in four programs

Factor analysis 2: The answers not filled out were left blank. The factors number were determined by the application

Characteristic	Factor									
	Integration	Rules	Materials	Cohesion	Rules and Cohesion	Materials	Rules	Rules	Materials	Cohesion
Questions No.	1, 5, 9, 13 17, 21	2, 14	12, 16	19	15, 18	3, 11	16, 20	4, 24	22	8
Eigenvalues	6.38	2.79	1.85	1,59	1.30	1.13	0.97	0.93	0.83	0.81
Explained variance (%)	26.59	11.64	7.72	6.63	5.45	4.72	4.06	3.88	3.48	3.38

Total variance: 77.56%
Factor loadings smaller than 0.4 omitted
The sample consisted of 174 students in four programs

Table 3 Factor analysis results for the SASLEI

Question No.	Factor loadings			
	Integration FA1–FA2	Rules FA1–FA2	Materials FA –FA2	Cohesion FA1–FA2
17	0.83-0.83			
21	0.79-0.76			
9	0.79-0.78			
1	0.76-0.86			
5	0.71-0.80			
13	0.70-0.79			
7		0.72-0.67		
10		0.66-0.55		
2		0.62-0.62		
6		0.53-0.66		
14		0.52-0.58		
16			0.78-0.83	
12			0.70-0.68	
20			0.54-0.61	
8			0.42-0.50	
11				0.68-0.56
3				0.67-0.44
23				0.60-0.64
19				0.57-0.71
Eigenvalue	6,05-6.38	3.24-2.79	1.54-1.85	1.36-1.59
Explained variance (%)	25.24-26.60	13.49-11.64	6.40-7.72	5.65-6.63

Factor loadings smaller than 0.4 omitted
The sample consisted of 174 students in four programs
FA1: The answers not filled out were scored as 3. The factors number were determined by the application
FA2: The answers not filled out were left blank. The factors number were determined by the application
Total variance (%): FA1: 50.78, FA2: 52.59

Table 4 Internal consistency (Cronbach's alpha) of the SASLEI

Scale	Alpha reliability				
	Biology	Marine Sciences	Nursing	Human Nutrition	Total
Integration	0.83	0.88	0.88	0.81	0.91
Rules	0.69	0.63	0.71	0.34*	0.72
Cohesion	0.62	0.45*	0.65	0.63	0.60
Materials	0.64	0.32*	0.74	0.63	0.60
Total	0.86	0.68	0.83	0.79	0.83

*Scales with low reliability (<0.60).

Table 5 Means (M) and standard deviations (SD) of SASLEI scales for the total sample (A) and by College (B and C) and for the SLEI (Fraser and Lee, 2009)

Scale	Total Sample (A)	College of Health Sciences (B)	College of Experimental Sciences (C)	Significance* (Difference B-C)	Study by Fraser and Lee (2009)
	M (SD)	M (SD)	M (SD)		M (SD)
Integration	3.19 (1.01)	3.79 (0.72)	2.54 (0.87)	F = 109.17, p <0.01	3.94 (0.70)
Rules	3.95 (0.67)	4.16 (0.57)	3.72 (0.70)	F = 20.26, p <0.05	3.65 (0.74)
Cohesion	4.15 (0.58)	4.10 (0.58)	4.20 (0.57)	NS	3.73 (0.39)
Materials	3.70 (0.71)	3.83 (0.62)	3.55 (0.77)	F = 6.85, p <0.05	3.21 (0.89)
Total	3.74 (0.50)	3.97 (0.41)	3.50 (0.48)	F = 48.95, p <0.05	

(A) 174 students in the study, (B) Students in the *College of Health Sciences*, (C) Students in the *College of Experimental Sciences*.
*Significant differences between the scores of the Colleges (B-C) based on one-way ANOVA and Scheffe test, p <0.05, *NS*: not significant.

Table 6 Results of one-way (*) and two-way (**) ANOVAs for significance of differences between students of four programs for the SASLEI scales.

Program	M (SD)	Program	M (SD)	Significance
Integration ($F_{3,\,172}$ = 47.33, $p \leq 0.0001$)**				
Nursing	3.87 (0.74)	H. Nutrition	3.61 (0.64)	*NS*
Nursing	3.87 (0.74)	Biology	2.90 (0.79)	F = 14.74; p <0.05)*
Nursing	3.87 (0.74)	Marine Sci.	2.17 (0.81)	F = 42.27; p <0.05)*
Biology	2.90 (0.79)	H. Nutrition	3.61 (0.64)	F = 5.00; p <0.05)*
Biology	2.90 (0.79)	Marine Sci.	2.17 (0.81)	F = 6.25; p <0.05)*
Marine Sci.	2.17 (0.81)	H. Nutrition	3.61 (0.64)	F = 19.17; p <0.05)*
Rules ($F_{3,\,172}$ = 11,69, $p \leq 0.0001$)**				
Nursing	4.28 (0.55)	H. Nutrition	3.85 (0.51)	F = 3.09; p <0.05)*
Nursing	4.28 (0.55)	Biology	3.86 (0.68)	F = 4.13; p <0.05)*
Nursing	4.28 (0.55)	Marine Sci.	3.58 (0.71)	F = 10.83; p <0.05)*
Biology	3.86 (0.68)	H. Nutrition	3.85 (0.51)	NS*
Biology	3.86 (0.68)	Marine Sci.	3.58 (0.71)	NS*
Marine Sci.	3.58 (0.71)	H. Nutrition	3.85 (0.51)	NS*
Cohesion ($F_{3,\,172}$ = 1.61, $p \leq 0.19$)**				
Nursing	4.16 (0.57)	H. Nutrition	3.98 (0.60)	NS*
Nursing	4.16 (0.57)	Biology	4.10 (0.66)	NS*
Nursing	4.16 (0.57)	Marine Sci.	4.30 (0.46)	NS*
Biology	4.10 (0.66)	H. Nutrition	3.98 (0.60)	NS*
Biology	4.10 (0.66)	Marine Sci.	4.30 (0.46)	NS*
Marine Sci.	4.30 (0.46)	H. Nutrition	3.98 (0.60)	NS*
Materials ($F_{3,\,172}$ = 0.65, $p \leq 0.58$)**				
Nursing	3.86 (0.62)	H. Nutrition	3.76 (0.61)	NS*
Nursing	3.86 (0.62)	Biology	3.58 (0.70)	NS*
Nursing	3.86 (0.62)	Marine Sci.	3.52 (0.86)	NS*
Biology	3.58 (0.70)	H. Nutrition	3.76 (0.61)	NS*
Biology	3.58 (0.70)	Marine Sci.	3.52 (0.86)	NS*
Marine Sci.	3.52 (0.86)	H. Nutrition	3.76 (0.61)	NS*

*One-way ANOVA.
**Two-way ANOVA: X = Program, Y = Scales.
NS: not significant.
F = Scheffe test, p <0.05; NS: not significant.
Student number (N): Nursing (64), Human Nutrition (26), Biology (44) and Marine Sciences (40).

Table 7 Means (M), standard deviations (SD) and significance of differences between males and females for SASLEI scales for the total sample and by colleges and programs.

Scales	Females M (SD)	Males M (SD)	Significance*
	Total sample		
	N = 123	N = 51	
Integration	3.35 (0.90)	2.81 (1.15)	$F = 10.86$; $p < 0.01$
Rules	4.02 (0.61)	3.78 (0.77)	$F = 4.66$; $p < 0.03$
Cohesion	4.19 (0.56)	4.02 (0.62)	NS
Materials	3.72 (0.68)	3.65 (0.78)	NS
Total	3.91 (0.46)	3.74 (0.53)	$F = 4.51$; $p < 0.03$
	College of Experimental Sciences		
	N = 47	N = 37	
Integration	2.67 (0.85)	2.40 (0.88)	NS
Rules	3.88 (0.64)	3.55 (0.73)	$F = 4.66$; $p < 0.03$
Cohesion	4.35 (0.45)	4.00 (0.67)	$F = 8.62$; $p < 0.01$
Materials	3.58 (0.77)	3.53 (0.79)	NS
Total	3.82 (0.52)	3.59 (0.49)	$F = 4.34$; $p < 0.04$
	Biology Program		
	N = 23	N = 21	
Integration	3.16 (0.61)	2.58 (0.85)	$F = 6.78$; $p < 0.01$
Rules	4.12 (0.50)	3.57 (0.75)	$F = 8.27$; $p < 0.01$
Cohesion	4.40 (0.45)	3.77 (0.70)	$F = 12.84$; $p < 0.01$
Materials	3.88 (0.60)	3.25 (0.64)	$F = 11.87$; $p < 0.01$
Total	4.04 (0.45)	3.42 (0.48)	$F = 19.21$; $p < 0.01$
	Marine Sciences Program		
	N = 24	N = 16	
Integration	2.19 (0.78)	2.18 (0.88)	NS
Rules	3.65 (0.69)	3.52 (0.73)	NS
Cohesion	4.31 (0.45)	4.29 (0.52)	NS
Materials	3.30 (0.82)	3.90 (0.85)	NS
Total	3.62 (0.50)	3.82 (0.43)	NS
	College of Health Sciences		
	N = 76	N = 14	
Integration	3.78 (0.63)	3.89 (1.11)	NS
Rules	4.11 (0.58)	4.41 (0.44)	NS
Cohesion	4.10 (0.60)	4.16 (0.44)	NS
Materials	3.80 (0.61)	3.98 (0.68)	NS
Total	3.97 (0.41)	4.14 (0.41)	NS
	Nursing Program		
	N = 52	N = 12	
Integration	3.87 (0.61)	3.87 (1.20)	NS
Rules	4.24 (0.56)	4.46 (0.46)	NS
Cohesion	4.15 (0.62)	4.17 (0.29)	NS
Materials	3.82 (0.61)	4.00 (0.68)	NS
Total	4.04 (0.41)	4.16 (0.37)	NS
	Nutrition and Dietetics Program**		
	N = 24	N = 2	
Integration	3.58 (0.65)	4.00 (0.47)	NS
Rules	3.82 (0.53)	4.12 (0.18)	NS
Cohesion	4.00 (0.56)	4.10 (1.27)	NS
Materials	3.75 (0.61)	3.87 (0.88)	NS
Total	3.80 (0.36)	4.00 (0.78)	NS

* One-way ANOVA; F = Scheffe test, $p < 0.05$; NS: not significant.
** The significance of these data is not valid, given that there were only two male subjects