Revista Odontológica Mexicana

Facultad de Odontología

Vol. 18, No. 2 ● April-June 2014

pp 120-127

ORIGINAL RESEARCH

Molecular biology protocols assessment in the Biochemistry subject of the National School of Dentistry, National University of Mexico (UNAM)

Evaluación de protocolos de biología molecular en la asignatura de Bioquímica de la Facultad de Odontología, Universidad Nacional Autónoma de México

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ABSTRACT

For over a decade, experimental teaching of Biochemistry as a subject has been reinforced as part of the School of Dentistry, National University of Mexico (UNAM) curriculum. This aim has been achieved with the help of laboratory practices. The project of strengthening biochemistry teaching, entailed the purpose of achieving, for the student, the comprehension of biochemistry and molecular biology basic concepts and thus improving their professional skills. With this purpose in mind, three molecular biology experimental protocols have been introduced in the scholastic cycle 2011-2012. **Objective:** To analyze in the 2011-2012 generation, the opinion survey sustained on molecular biology protocols. **Materials and methods:** In an blind and voluntary basis, an opinion survey was applied to first year students of the National School of Dentistry. In this survey, six aspects of molecular biology protocols were assessed. The six aspects were: learning, participation, planning, group interaction, evaluation and infrastructure. Standard deviation means were obtained (± SD) in order to assess instrument reliability. Internal consistency of the survey and evaluation percentage of each reactive were equally obtained. To achieve this aim, the SPSS Windows version 12 was used. Averages of different categories were as follows: learning 71.1% (± 12.5), evaluation: 78.6% (± 17.1); infrastructure: 81.8% (± 17.9%). Global assessment revealed a 78.1 ± 10.3. Internal consistency of the survey presented a Crombach alpha of global 0.889. Survey of analysis results suggested that contemporary training for dentistry students must combine the didactic experience of laboratory work along with classroom activities. Infrastructure must nevertheless be potentiated as well as the student's skills to interpret results.

Key words: Biochemistry, molecular biochemistry, survey, protocols' assessment.

Palabras clave: Bioquímica, biología molecular, encuesta, evaluación de protocolos.

RESUMEN

Desde hace más de un década, se ha reforzado la enseñanza experimental de la asignatura de Bioquímica en la Facultad de Odontología mediante la implementación de prácticas de laboratorio. El proyecto sobre el fortalecimiento de la enseñanza en bioquímica tiene la intención de que el estudiante sea capaz de comprender los conceptos básicos de bioquímica y biología molecular con la finalidad de que los estudiantes mejoren sus competencias profesionales. Con este propósito, en el ciclo escolar 2011-2012, se han introducido tres protocolos experimentales en el ámbito de la biología molecular. **Objetivo:** Analizar la encuesta de opinión sobre los protocolos de biología molecular en la generación 2011-2012. **Material y métodos:** Se aplicó una encuesta a los estudiantes del primer año de la Facultad de Odontología, la cual se resolvió de manera anónima y voluntaria, en la que se evaluaron seis aspectos sobre los protocolos de biología molecular, que consistieron en: aprendizaje, participación, planificación, interacción con el grupo, evaluación e infraestructura. Se obtuvieron las medias y desviación estándar (± DE) para evaluar la confiabilidad del instrumento; así mismo, se obtuvo la consistencia de interna de la encuesta y el porcentaje de evaluación de cada reactivo. Se utilizó el programa SPSS para Windows versión 12. **Resultados:** Participaron un total de 430 estudiantes. La media de las diferentes categorías fueron las siguientes: aprendizaje 71.1% (± 13); participación 91.85 (± 11.7); planificación 77.1 (±12.5); evaluación 78.6% (± 17.1); infraestructura 81.8% (± 17.9). La evaluación global presentó un porcentaje de 78.1 ± 10.3. Así mismo, la consistencia interna de la encuesta presentó un alfa de Crombach de 0.889 global. Los resultados obtenidos del análisis de la encuesta sugieren que la formación contemporánea para los estudiantes de odontología debe combinar la experiencia didáctica de trabajo en el laboratorio junto con actividades en el aula. Sin embargo, deberá ser potenciada la infraestructura y fomentar la capacidad de los estudiantes para interpretar resultados.

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INTRODUCTION

Practice of dentistry remained virtually static in the 20th century. After this date, new products, materials and techniques were introduced which enabled completion of efficient treatments). Nevertheless, upon the onset of the 21st century, biochemical and technological sciences achieved through a greater knowledge of biomolecules, as well as the application of different technologies, a major impact in society in the course of their search to improve human health. Dental practice could be no exception. Biochemistry and molecular biology techniques have made their presence felt in diagnosis, risk evaluation, prevention as well as many other clinical aspects of dentistry.[1-5] Advances mainly target the biochemical-molecular aspects of connective tissue in tissue regeneration biochemistry, biochemistry and gene therapy molecular biology, as well as studies on drug release and the dynamics of their transportation.[6-9] All the aforementioned ride alongside to the search for knowledge related to macromolecular architecture, protein structure and molecular therapies.[10,11] On the other hand, in the realm of commercial markets, there are devices related to diagnosis and risk of caries or periodontal disease based on genetic polymorphisms and on techniques associated to molecular biology. Likewise, with the development of new diagnostic techniques in saliva samples, dentistry has assumed the forefront of systemic health vigilance as well as in the risk surveillance of contracting diseases.[12-15] For this reason, different techniques derived from biochemistry such as genomic or proteomic application in the varied diagnosis tests and in preventive measures require that students, teachers and professionals acquire the required knowledge with respect to human and molecular medicine genetics in order to achieve efficient diagnosis and treatments.[16-22]

In this respect, the issues addressed in the Biochemistry subject at the National School of Dentistry encompass topics of study covering structure and function of biomolecules, cell metabolism and molecular biology. A total of 14 hours is devoted to molecular biology. Due to this reason, and as a part of the financial support granted by the Program for Support for Innovation and Improvement of Teaching at the National University of Mexico, three protocols have introduced molecular biology elemental techniques. Therefore, the time devoted to this subject encompasses now a total of 20 hours, divided into theory and practice.

Molecular biology protocols target the teaching of certain available experimental strategies used to manipulate, isolate and characterize nucleic acids, that is to say deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Research for these procedures initiated in the 1950s and 1960s. Many research projects of prominent scholars emerged at that time. These projects were devoted to DNA and RNA isolation as well as characterization of enzymes involved in the transcription and translation. Cloning is one of the elemental molecular biology techniques to study protein function. In this technique, the protein of interest is cloned through the use of different enzymes, among which the restriction enzymes can be found, in a plasmid designed as well as an expression vector. The plasmid contains three fundamental elements which are: a replication origin, a region acting as an antibiotic resistance marker, which allows plasmid follow-up, and a region called multiple cloning region. This region is recognized by different restriction enzymes, thus allowing insertion of the proteins of interest.

With the aim of reviewing cloning basic techniques, students perform bacterial transformation. This procedure consists upon capturing exogenous DNA contained in a plasmid, with the help of the competent *Escherichia coli bacteria* (DH 5α). Transformed bacteria selection is likewise undertaken, by means of their growth in a culture medium containing antibiotics. Ampicillin was used in the present case. In a similar manner, once selection had been established, the techniques of isolation and linearizing of the plasmid by restriction enzymes were undertaken. Visualization of this latter procedure was equally taught with the technique of electrophoresis in agarose gels. Finally, the expression of the protein contained in the plasmid was analyzed. In the present case it was the fluorescent green protein observed when bacteria are illuminated with ultraviolet light *(Figure 1)*.

Due to the aforementioned motives, the objective of the present research was to analyze a survey on the perception shown by students with respect to molecular biology protocols. Prior to analyzing the survey, it was deemed necessary to ascertain the psychometric properties of the instrument used.

Obtained results showed the fact that application of the survey to assess molecular biology protocols is a useful tool in order to analyze new teaching strategies as well as the impact exerted upon the improvement of basic science teaching.

Results of the survey analysis suggested that the use of cutting-edge techniques in the realm of molecular biology motivated students to improve the understanding of the subject as well as defining its importance in the application of basic sciences in medical practice.

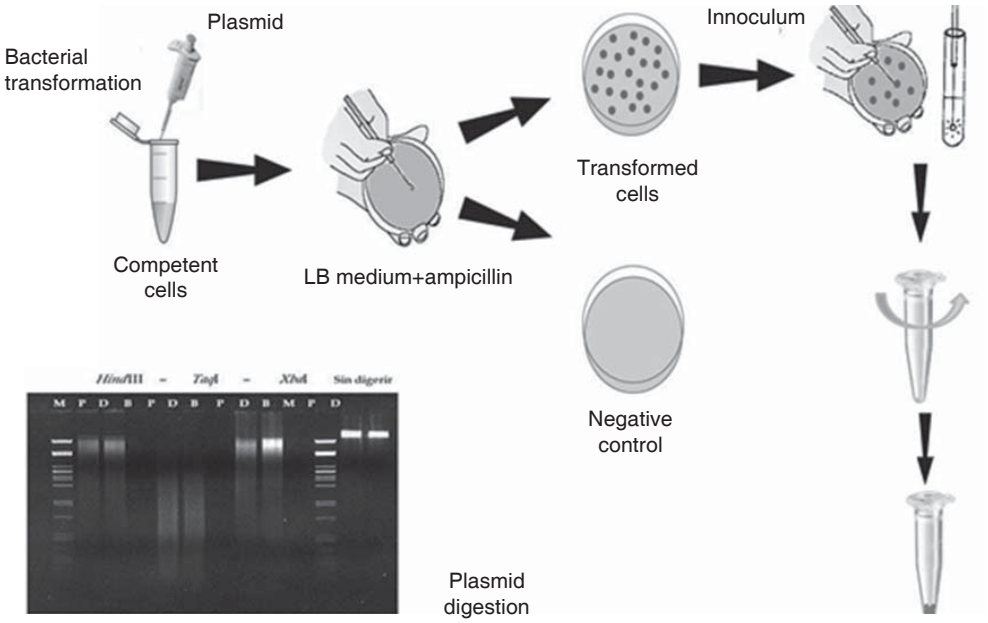

Figure 1.

Diagram showing bacterial transformation, isolation, plasmid digestion and protein expression.

MATERIAL AND METHODS

The study project was undertaken at the end of the 2011-2012 school year. That student generation undertook the three molecular biology protocols, with the aim of assessing perception of students who studied Biochemistry as a part of their dental schooling.

Molecular biology protocols evaluation questionnaire as part of their experimental teaching

Questionnaires were handed out to first year students at the National School of Dentistry, National University of Mexico (UNAM) Participation was volitional and anonymous. Approximately 30 minutes were required to complete the questionnaire.

The questionnaire was composed of 24 questions organized in six categories: 1) learning (determines the process by which new skills are acquired); 2) participation (determines the ability to get involved); 3) planning (determines whether the teacher promoted a conductive environment in the laboratory; 4) group interaction (determines student ability to work in groups); 5) assessment (determines the teacher's supervision and analysis as well as obtained results; 6) infrastructure (determines whether the reagents and teams are sufficient for practice development) *(Table I)*.

Criteria for score assessment

A Likert-type response format was used, with values ranging from 1 to 5. They were divided into: very much in disagreement (1); in disagreement (2), neutral (3), in agreement (4); very much in agreement (5) *(Table II)*.

Internal consistency of molecular biology protocols survey

Cronbach's alpha coefficient was calculated to determine the internal consistency of the evaluation questionnaire of molecular biology protocols.

Fundamental and underlying dimensions were explored. This was achieved with a factorial analysis with factor extraction through the method of main components, and a later rotation through the varimax octagonal method. Factorial analysis adequacy was assessed through the Kaiser-Meyer-Olkin test as well as Bartlett's sphericity test.

Assessment index of molecular biology protocols

A summation of criteria for the frequency of assessment scores of the following categories was obtained: learning, participation, planning, group interaction, assessment and infrastructure. They were divided into the maximum score (120). This result was multiplied by 100 *(Table II)*.

Table I. Categories and evaluation elements applied to Biochemistry experimental course students.

Evaluation survey of molecular biology practices
Learning
1. I have learned and understood the contents of molecular biology practices.
2. My interest in the subject has increased as a result of molecular biology practices.
3. To which extent has the student potentiated the information understanding and synthesis ability.
4. To which extent has your ability to understand and handle the scientific method been improved.
5. To which extent has your ability to discuss and work in a team been improved.
6. To which extent has your capacity to interpret results been improved.
Participation
7. I have regularly attended laboratory practices.
8. I have actively participated in experimental sessions.
9. I have actively participated in report elaboration.
Planning
10. Course material was well prepared.
11. The teacher has carefully explained the objective and experimental procedure to undertake.
12. Practices have been well organized.
13. Practices have been conducted according to program.
14. I have received the protocol syllabus during the first week of the course.
15. I have previously studied the protocol to be undertaken.
Group interaction
16. Team work groups have been a suitable tool to study, learn the subject, and share knowledge and ideas.
17. Working environment fosters questions from the students.
18. Satisfactory responses were obtained.
19. I have attended all sessions with necessary material prepared.
20. I have kept a responsible and positive attitude towards other members of the work team.
Evaluation
21. Evaluation methods are fair and adequate.
22. Contents of exams and other assessed works correspond to course contents and are in accordance with the emphasis placed by the teacher in every subject.
Infrastructure
23. The team used is appropriate to the development of each practice.
24. The use given to the laboratory material is appropriate.

Evaluation (assessment) index of molecular biology protocols EIMBP

$$EIMBP = \sum [(learning) + (participation) + (planning) + (group\ interaction) + (evaluation) + (infrastructure)/120)]^* 100$$

Results analysis

Molecular biology protocols assessments were conducted through obtainment of means, standard deviation (± 1 SD) and percentages. The program SPSS for Windows version 12 was used.

RESULTS

Participation was 77.75% (n = 430) out of 553 first year dental students (school year 2011-2012) at the National School of Dentistry, National University of Mexico (UNAM).

Internal consistency of molecular biology practices evaluation survey

Internal consistency of the molecular biology practices evaluation survey achieved 0.899 statistical reliability, according to Cronbach's alpha analysis. *Table III* depicts internal consistency of dimensions assessed in the evaluation service of molecular biology practices. Factorial analysis revealed that the six dimensions were integrated into four factors capable of explaining 52% of total variance. Factors outlined with the factorial analysis were presented in the following order: a) syllabus and organization of practices accomplishment (31.1% of variance); b) student interest in practices (9.5% of variance), c) student's acquired ability during practices accomplishment (6.7% of variance), and d) teacher's commitment in teaching (5.2% of variance). Kaiser-Meyer Olkin's statistical measure of sampling adequacy was 0.89, Bartlett's sphericity test was 0.003, with 276 degrees of freedom ($p < 0.001$). All the aforementioned factors suggested the instrument was acceptable to undertake evaluation.

Table II. Criteria for score frequency evaluation.

Frequency	Score (points)
Very much in disagreement	1
In disagreement	2
Neutral	3
In agreement	4
Very much in agreement	5

Evaluation index of molecular biology protocols (EIMBP)
EIMBBP = $\sum$ [(learning) + (participation) + (planning) + (group interaction) + (evaluation) + (infrastructure)/120]* 100

Table III. Internal consistency of evaluation service of molecular biology practices.

Assessed dimensions	Crombach's alpha
Learning	0.812
Participation	0.741
Planning	0.729
Group interaction	0.708
Evaluation	0.746
Infrastructure	0.780
Global evaluation	0.889

Score obtained in molecular biology practices evaluation

Score mean for the different assessed dimensions revealed that the dimensions: participation (91.8); planning (77.1); group interaction (77.7); evaluation (78.6), and infrastructure (81.8) exhibited a value close to the maximum *(Table IV)*. Nevertheless, the learning dimension (71.1) did not show a satisfactory result. Due to this reason, for each reactive, a percentile analysis was undertaken in order to determine which factor of the learning model was not satisfactory to the students.

Reactive evaluation percentage

Evaluation percentages analysis revealed that the learning dimension reactive showed that molecular biology protocols were especially important in order to increase interest in Biochemistry *(Table V)*. Likewise, these protocols were clear with respect to the learning objective, they potentiated the ability to handle the scientific method, as well as interpret results and work in a team. With respect to the participation dimension, students showed interest in experimental activities and assistance compliance. Students equally considered satisfactory the materials and teacher's knowledge on the subject as well as fair evaluation. All the aforementioned factors suggested the fact that molecular biology research protocols were a useful tool to potentiate their analysis ability of the scientific method.

DISCUSSION

Results obtained from the molecular biology protocols assessment survey revealed the fact that implementation of molecular biology protocols was an

Table IV. Score obtained at the molecular biology practices evaluation survey.

Assessed dimensions	Score min.-max.	Mean ± 1 SD
Learning	23.3-100.0	71.1 ± 13.0
Participation	20.0-100.0	91.8 ± 11.7
Planning	20.0-100.0	77.1 ± 13.5
Group interaction	36.0-100.0	77.7 ± 12.5
Evaluation	20.0-100.0	78.6 ± 17.1
Infrastructure	20.0-100.0	81.8 ± 17.9
Global evaluation	39.2-100.0	78.1 ± 10.3

Table V. Percentages of the survey on molecular biology practices evaluation (n = 430).

Reactive	Very much in disagreement	In disagreement	Neutral	In agreement	Very much in agreement
Learning					
- I have learned and understood the contents of molecular biology practices.	2.1	10.0	38.5	40.3	8.9
- My interest in the subject has increased as a consequence of molecular biology practices.	7.9	14.9	36.4	29.8	11.0
- In which measure has increased your ability to synthesize and understand the information.	1.4	6.8	37.8	42.7	11.2
- In which measure has increased your ability to understand and handle the scientific method.	0.7	4.2	28.9	47.8	18.4
- In which measure has increased your ability to discuss and work in a team.	2.6	7.2	27.0	44.8	18.4
- In which measure has increased your ability to interpret results.	1.9	5.8	32.4	44.8	15.2
Participation					
- I have regularly attended laboratory practices.	0.2	1.2	2.8	10.7	85.1
- I have actively participated in experimental sessions.	0.7	2.6	9.3	29.4	58.0
- I have actively participated in reports preparation.	0.5	1.4	6.5	24.2	67.4
Planning					
- Course material was well prepared.	1.6	8.4	22.8	42.7	24.5
- The teacher carefully explained objectives and experimental procedures to undertake.	1.4	5.6	19.3	38.5	35.2
- Practices were well organized.	1.2	7.0	26.1	41.5	24.0
- Practices were conducted according to program.	3.0	5.6	14.0	34.0	43.4
- I received protocols syllabus during the first week of the course.	8.2	9.1	14.7	18.4	49.7
- I have previously studied the protocol to undertake.	4.0	8.9	36.6	33.8	16.8
Group interaction					
- Team work groups have been a suitable tool to study, learn the subject and share knowledge and ideas.	5.1	10.7	31.5	32.2	20.5
- Working environment encourages questions from the students.	4.0	11.2	33.6	35.7	15.4
- Satisfactory responses were achieved.	2.1	6.1	32.2	42.0	17.7
- I have attended all sessions with necessary material prepared.	0.7	2.6	9.3	34.5	52.9
- I have exhibited a responsible and positive attitude towards other members of the work team.	0.2	2.1	7.9	38.2	51.5
Evaluation					
- Evaluation methods are equitable and suitable.	3.0	4.9	21.7	42.2	28.2
- Contents of exams and other assessed work correspond to course contents and were in concordance with the emphasis placed by the teacher on the subject.	2.1	5.1	17.0	43.6	32.2
- Equipment used was adequate for the development of each practice.	4.0	7.5	14.2	39.6	34.7
- Use given to laboratory material was adequate.	2.1	2.8	10.0	37.8	46.4

important methodological tool in order to familiarize students to basic sciences and research. Due to this motive, in the Biochemistry subject, it would be important to promote active and cooperative learning processes, aimed at potentiating the professional skills of the dentist.

It is interesting to point out that bearing in mind the speed with which knowledge advances and its access through communication and information technologies, it is imperative for health professionals who have clinical practice as their main objective to be cognizant of scientific and technological advances as well as to link this knowledge with its clinical applications. Likewise, biomedical sciences and technology are concepts which are headed towards the improvement of health. Many research groups are currently working in these areas of knowledge, especially in the field of genomic research, which has achieved great contributions to the study of genes and their role in sickness and health. The field of oral health could be no exception; it is currently possible that knowledge contributed by biochemistry and molecular biology might have high coincidence with activities undertaken in the clinic.[23-27] Thus, the understanding of main conditions in the field of dentistry, such as caries and periodontal disease –which are conditions whose etiology has been widely documented and are the product of conjunction among microorganisms with genetic and environmental factors– have been contributory. For these reasons, many research projects have targeted achieving a co-relation among these dental diseases with other systemic diseases, and thus achieve identification of risk factors associated to the development of these diseases. Likewise, the field of tissue regeneration has emerged from different studies performed with stem cells. Moreover, research conducted in genomics and proteomics has fostered, in 2007, the publication of the complete saliva proteome as well as the use of *affymetrix chips* in order to detect susceptibility to periodontal disease development.[28-30]

Moreover, participatory learning is effective in university students since it implies for the student to actively engage in his own learning process. Thus, acquired knowledge will become independent and self-directed, and the student will learn how to develop critical reasoning and to write clear and precise prose.[25,26,31]

CONCLUSIONS

The present research project was framed within the Institutional Development Plan of the National School of Dentistry, National University of Mexico (UNAM). The project conducted an analysis of the application of research protocols which allowed the reinforcement of basic sciences, especially in the realm of Biochemistry. Results obtained revealed that the introduction of these activities in the first year syllabus is positive, and that the detailed planning of these protocols is correct. This entails problem solution, team work promotion as well as fostering critical reasoning among students at the School of Dentistry.

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