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APPLYING A PROJECT-BASED LEARNING METHODOLOGY TO TEACH GENE CLONING STRATEGIES

Ana Cláudia Sousa, Sónia Santos, Natália Osório, Ana Gabriela Gomes e Marta Campos Justino

Centro Interdisciplinar de Ciências Químicas e Biológicas do Instituto Politécnico de Setúbal (CIQuiBio-IPS); Escola Superior de Tecnologia do Instituto Politécnico de Setúbal (ESTBarreiro/IPS)

Project-based learning (PBL) is an active student-centred form of instruction that uses a project as central vehicle of knowledge acquisition. Besides its high potential in developing a structured thinking, constructive investigations and improve the students' responsibility and autonomy, this methodology is not strongly applied in Science degrees, where standardized tests and fixed protocol-driven laboratorial applications still represent the majority of ways to assess academic achievement. In the context of Genetic Engineering, the bridge between the theoretical conception of a cloning strategy and its' concretization in a stepwise practical implementation is a hard skill for students to achieve.

To overcome this learning struggle, a PBL was applied to 3rd-year students of the BSc Biotechnology course, integrating two curricular units: Genetic Engineering and Integrated-Laboratories. The objective of the PBL was to allow the students to: 1)create a cloning strategy; 2)develop their own protocol to implement it, and 3)execute it in the laboratory. Students were grouped in three laboratorial classes, each challenged with a different cloning strategy.

This PBL study was developed in four stages: first, the project was conceptualised in Genetic Engineering theoretical classes, for tutorial support. Secondly, the students applied their planned protocol in the laboratory, also with tutor supervision. Thus, they were able to evaluate the experimental conditions that led to the best cloning results. Thirdly, the collaboration, communication and reflection skills were worked, with a poster presentation. Lastly, an evaluation questionnaire (N=39) was applied and data statistically treated. The main conclusions were: 1)none of the students had ever used such a methodology, 2)the majority were able to better understand and acquired sounder theoretical knowledge, 3)gained more autonomy in the laboratory and 4) strongly recommended this methodology. Despite all positive aspects referred, students also mentioned that PBL was more time and study-demanding, if a more effective way to learn.

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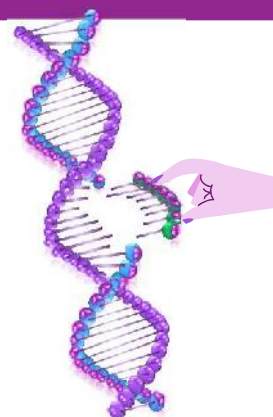
²Escola Superior de Tecnologia do Instituto Politécnico de Setúbal (ESTBarreiro/IPS)

Introduction

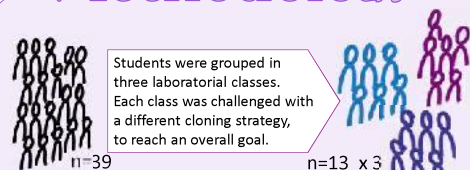
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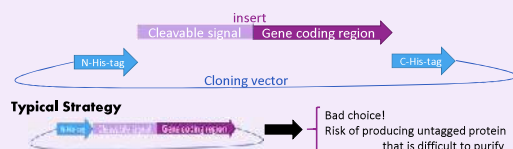


Methodology

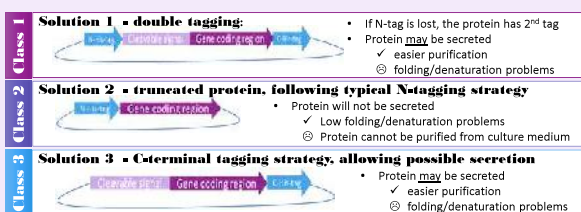


Step by step planning the cloning strategy:

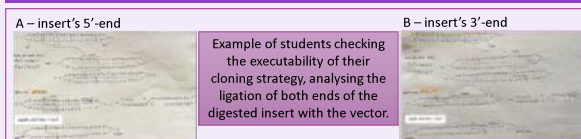
- Students were challenged to develop cloning strategies that would enable the production and easy purification of a recombinant protein.
- Specific problems were posed due to a) the characteristics of the gene, since its origin is from an unsequenced strain and b) the multiplicity of cloning strategies available considering the properties of the chosen cloning vector:
 - Positioning of the His-Tag (at the N-terminal or C-terminal)
 - Presence of a potential signal peptide for secretion in the gene (that could lead to the loss of N-terminal tags)
 - Using conserved regions of the gene sequence, based on the alignment of sequenced genomes, to choose the primer location (primer design)



- Three specific strategies were proposed and students were randomly assigned one, based on their laboratory class schedule and grouping (3-4 elements).



- Choice of restriction enzymes was narrowed to those available at the Lab.
- The design of the insert's amplification primers was guided: each class was given a proposal to validate (for position, for conservation 3'-end sequence and for in-frame tag(s) insertion).



Creation of a laboratorial protocol to implement the cloning strategy

- Students were given conditions – in computer classrooms – to create their protocols, namely access to brand's sites of enzymes and kits at their disposal in the lab, to retrieve technical information.
- For simple procedures that students had previously performed, adaptation of those protocols was suggested, while for novel procedures bibliographic sources were recommended.
- Team work was reinforced. Each group planned to test different PCR conditions – enabling each class, as a whole, to do a thorough optimization (temperature, buffer's composition and primers' concentration)

Laboratory implementation

- Three 3h-laboratory classes were used. Intermediary results were discussed in GE classes.
- In the lab, the teacher's role was minor, monitoring for correct handling and lab practices, providing the reagents, equipment and tools that students were asking for.
- Students worked semi-autonomously providing a training for their upcoming internship.
- Students were faced with real-life (untested) lab procedures, a.k.a., not all procedures gave positive results, demonstrating the need for optimizations.

Global results of the PCR amplification	
Class 1	one good condition - Buffer HF + 0,5 uM primers
Class 2	one good condition - Buffer GC + 1uM primers
Class 3	None of the conditions allowed PCR amplification

- When only one group had positive reactions, these were shared with the rest of the class to clean and digest, and were reunited again for the ligation (in order to obtain higher yields).
- Class 3 performed mock clean-up (to execute once the novel procedure) and used inserts prepared in the other classes in their ligations

PBL Evaluation

After the PBL, students were asked to answer a 2-part anonymous questionnaire:

- Part A addressed the characterization of the students' profile
- Part B addressed the evaluation of the PBL's implementation

Part A: Students' profile

- Total of 39 students, enrolled in the 3rd year of Biotechnology BSc course
- Only one student was enrolled for the 2nd time in the Curricular Unit
- 64% are females and 36% are males
- Age average of 22,8 years (mode = 22 years, in a range of 20 – 44)
- Geographically distributed over 16 municipalities, 69% of the students live in the Setúbal County, 26% in the Lisbon County and 5% in two other Counties.
- 15% are working-students
- 100% never had done PBL

Part B: Students' assessment of PBL's implementation

The evaluation questionnaire combined 12 randomly distributed questions (A to L) addressing three topics:

- Global satisfaction (n=4)
 - Knowledge acquisition (n=4)
 - Comparison of PBL vs. traditional teaching methodologies (n=4)
- Grading interval from 1 (don't agree at all) to 5 (agree totally).

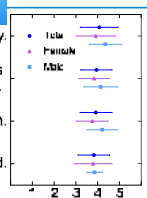
Global satisfaction

I really recommend this teaching methodology.

I received feedback over the tasks as I was planning/executing the project.

I was more motivated to learn.

I feel the project's main goal was achieved.



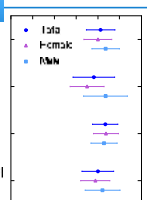
Knowledge acquisition

I have acquired more solid knowledge and skills with this teaching methodology.

Tutorial classes helped me learn basic concepts required to carry out the project.

I had a better understanding of the steps performed in the laboratory.

I understood better the theoretical concepts inherent to the project.



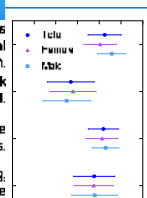
PBL vs. traditional teaching methodologies

The effort made to learn and develop the tasks was greater than with a less-dynamic theoretical teaching approach.

The accomplishment of the laboratory work was easier than if I were given a protocol.

I considered that it was very productive to have applied the project I developed in the practical classes.

I prefer this methodology to conventional teaching, where I am given me a protocol to perform the experimental work in lab classes.



Conclusions

Genetic Engineering is traditionally taught using a combination of lecture and laboratory sections. Recent teaching experiences, in this same Institute, allowed us to realise that many of the students memorize concepts and perform the lab tasks presented, without acquiring a global vision of the process itself.

To overcome this reality, the PBL as an educational strategy was applied in the third year of a BSc in Biotechnology. This student-centred methodology showed very good results. None of the 39 students were familiar with this teaching approach. All of them agreed that it was the best way to acquire theoretical knowledge, they felt more confident in their knowledge and although they consider it more demanding in terms of time and research work, all recommend it as a methodology to be applied in the future.

