José Alexandre de Carvalho Gonçalves ·
José Luís Sousa de Magalhães Lima ·
João Paulo Coelho ·
Francisco José García-Peñalvo ·
Alicia García-Holgado
Editors

# Proceedings of TEEM 2023

## The Eleventh International Conference on Technological Ecosystems for Enhancing Multiculturality

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*Editors*
José Alexandre de Carvalho Gonçalves
Research Centre in Digitalization
and Intelligent Robotics (CeDRI)
Polytechnic Institute of Bragança
Bragança, Portugal

José Luís Sousa de Magalhães Lima
Research Centre in Digitalization
and Intelligent Robotics (CeDRI)
Polytechnic Institute of Bragança
Bragança, Portugal

João Paulo Coelho
Research Centre in Digitalization
and Intelligent Robotics (CeDRI)
Polytechnic Institute of Bragança
Bragança, Portugal

Francisco José García-Peñalvo
GRIAL Research Group
University of Salamanca
Salamanca, Spain

Alicia García-Holgado
GRIAL Research Group
Universidad de Salamanca
Salamanca, Spain

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# Preface

This is the 2023 Technological Ecosystems for Enhancing Multiculturality Conference - TEEM 2023 Proceedings. TEEM Conference Proceedings reflect the most outstanding advances, with a multidisciplinary perspective, in the technological ecosystems that supports the Knowledge Society building and development. Informatics and Education are the central issues in the conference tracks, including broad-scope research areas, such as Educational Assessment and Orientation, Human-Computer Interaction, eLearning, Computers in Education, Communication Media and Education, Medicine and Education, Learning Analytics, Engineering Education, Mechatronics Education, Diversity in Education, Gamification and Games for Learning.

TEEM 2023 was divided into thematic and highly cohesive tracks. Each track was oriented to a specific community of interest, including researchers, professionals, students, etc. Also, the multidisciplinary approach allowed the cross-track interest, giving an extra value to the whole volume more than a specific article or track.

The TEEM 2023 active Tracks were:

Track 1: Gamification and Games for Learning (GAMILEARN)
Track 2: Managing Generative AI in Educational Settings
Track 3: Multidisciplinary technological resources applied to health sciences
Track 4: Engineering Education: Approaches to technology education and multiculturality
Track 5: New trends in Mechatronics Engineering Education
Track 6: Bridging the diversity gap in STEM
Track 7: Laboratories in STEM Education
Track 8: Data-Driven Education: Overcoming Hurdles for the Future of Learning Analytics
Track 9: Smart Learning
Track 11: Communication, Education and Social Media
Track 12: Identity and education. Identity construction processes in hyperconnected and natural ecosystems
Track 13: Educational assessment and guidance
Track 14: Educational Innovation:
Track 16: Doctoral Consortium

The Conference included two keynote lectures, of two well-known researchers, that have relevant contributions for the conference Thematic. The plenary speeches were:

"Inclusive User Experience (IUX) Design: Starting with Story"

Kelly Page, University of Colorado Denver, United States of America

"Teaching tools and methods for encouraging student engagement without overloading staff"

John Anthony Rossiter, University of Sheffield, United Kingdom

This Conference has a consolidated international community behind it. The research scope is multidisciplinary, but learning technologies is the main topic that joins the different thematic tracks that were included.

# Effective Solution Based Learning - Report of the experimental results

Paulo Matos[1], Rui Alves[2], Pedro Oliveira[3], and José Gonçalves[4]

[1] CeDRI—Research Centre in Digitalization and Intelligent Robotics, Polytechnic Institute of Bragança, Portugal.
pmatos@ipb.pt,
https://cedri.ipb.pt/people/integrated-members/paulo-matos
[2] Polytechnic Institute of Bragança, Portugal.
rui.alves@ipb.pt,
[3] CeDRI—Research Centre in Digitalization and Intelligent Robotics, Polytechnic Institute of Bragança, Portugal.
poliveira@ipb.pt,
https://cedri.ipb.pt/people/research-fellowships/pedro-oliveira
[4] CeDRI—Research Centre in Digitalization and Intelligent Robotics, Polytechnic Institute of Bragança, Portugal.
goncalves@ipb.pt,
https://cedri.ipb.pt/people/integrated-members/jose-goncalves

**Abstract.** The authors present the *Effective Solution Based Learning*, which derives from Project-Based Learning but is applied to real problems in order to build effective solutions. Emphasis is placed on the effectiveness on the assumption that encourages greater involvement and commitment on the part of students, ensuring a context that is intended to be more attractive and close to what will be their professional reality. Effectiveness is measured by the functionalities considered essential for solving the problem, but also the viability of the solution to be effectively used after the end of development, without the need for continued student involvement. A brief summary of the methodology is presented in the paper, emphasizing, in particular, the criteria and requirements for choosing project themes. The results of the first year of evaluation are also presented in the paper, pointing to a clear reduction in dropouts and an increase in approved students. Considering that this is achieved with more demand and work, it is arguable that it also resulted in students with more knowledge and skills. The authors also include in this paper the results of a survey done to the students, after the project conclusion, to assess the students' perspective on this methodology.

**Keywords:** Project Based Learning (PBL), Effective Solution Based Learning (ESBL), Software Development

## 1 Introduction

Within the scope of the curricular unit (CU) taught by the authors and taking advantage of the technological context and the need for more effective alternatives for learning and acquiring skills, the authors conceived and defined the

*Effective Solution Based Learning* (ESBL) – a methodology derived from the Project-Based Learning (PBL), that reinforces the use of real problems (relevant and requiring a solution) and working on the construction of effective solutions. Emphasis is placed on the effectiveness of the solution on the assumption that it encourages greater involvement and commitment on the part of students, promoting a context that is intended to be more attractive and closer to what the professional reality of students will be – encouraging an approach of learning to solve. Effectiveness aims to guarantee the functionalities considered essential for solving the problem, but also the viability of the solution to be effectively used after the end of development (end of the student's training period), without the need for any technical or maintenance support. As far as possible, it is also intended to ensure the financial viability of putting and maintaining the solution in operation (cloud, app stores, and the like).

In this paper, the authors characterize the methodology, presenting the restrictions/limitations and the requirements necessary to promote its success. It also presented the experiment that has been carried out to evaluate this form of learning, including the results of the first year of evaluation.

The paper contains six sections, organized as follows: the present introduction; Section 2 details the motivation of this work; Section 3 presents the research work carried out in the area; Section 4 presents part of the contribution of this initiative – defining the criteria and the transversal requirements for the eligibility of the projects; Section 5 five describes the evaluation scenario and presents the results achieved; and finally, in Section 6, the conclusions and future work.

## 2 Motivation

The curricular unit in question is central in the training of students in this area (computer engineering), as it is where they address technologies, methodologies, and work tools for the development of multiplatform applications (also known as hybrid applications) [1]. This technological approach presents enormous advantages for the companies that carry out development and, implicitly, for their clients – this is because, with a single development process, they ensure applications for more than one platform. By reducing the number of technologies in use, software developer's enterprises can be more specialized, have fewer sources of problems, have less training and licensing costs, and have more flexibility in human resources management.

This is not a recipe for all situations, there are always specificities that can only be ensured using the native technologies. However, the majority of applications do not require the use of native technologies. Considering that the existing technological solutions for multiplatform development already allow the production of applications conceptually with the same performance as those produced with native technologies, then is easy to understand the success of multiplatform development technologies [2].

All these arguments reinforce the need to ensure that this kind of curricular unit must be attractive, as complete as possible and that the learning and ac-

quisition of skills by trainees is effective and solid. Which is not a trivial task. Even considering the use of a single technological base, such as React Native, for example, it requires teaching a substantial amount of subjects (technical solutions), some of them complex as they result from specific problems of this type of development and, as such, unknown to the vast majority of students. In addition, most of them are immature technologies, with daily-based updates.

Then there are the problems whose resolution goes through code and configurations at the native level development, which desirably and conceptually shouldn't happen, but unfortunately happens – preventing or limiting the operation on certain platforms (iOS, Android, Windows, Web, ....), or requiring advanced knowledge on these platforms to get a solution.

It also happens that for the same technology, there may be different implementation abstractions [3]. For example, in React Native, it is possible to do development in React Native itself, in Expo (a little more accessible, at least until reach the production stage), or in React Native combined with native code/configurations (usually requiring good knowledge of native development). It is often necessary, to move from a higher abstraction level to a lower abstraction level, in order to be able to implement certain functionalities – a task that normally has costs, as it is common that the resolution of the basic problem gives rise to other problems.

In terms of work tools, the situation is not simple either – with contradictory opposites. There is a wide range of tools, such as integrated environments (Visual Code, WebStorm, ...), but also a lack of tools to ensure productivity, such as tools for debugging, inspection, or code profiling.

Then there are version compatibility issues between software packages (libraries). Technologies, such as React, are maintained by the open source community, with all its advantages, like a large number of available packages, and disadvantages, namely no guarantee of compatibility between the packages, nor technical support in the true sense.

Besides, much of the existing information is outdated or improperly contextualized – sometimes leading to solutions that only work for certain contexts or that don't work at all.

Whether due to the importance of this type of curricular unit for the training of students or due to the increased difficulties that learning and the acquisition of skills have in this area – which tends to result in very low approval rates, the situation required special attention by the teaching staff. It is in this context that the work reported in this paper was carried out, based on a strategy of learning through practice and, solving real and relevant problems.

## 3 Related Work

PBL is the subject of regular studies, with a considerable number of publications. We leave here a reference to the ones considered more relevant for the contextualization of our contribution.

In [4] an experience is reported with guiding principles similar to the ones reported in this paper. It is based on the PBL with real challenges posed by companies and with the active and direct involvement of students. The projects are developed using agile methodologies and conditioned to the use of open-access software. Despite the pertinence of the work and the results having been attested by a formal evaluation, the contribution of this paper, as their authors claim, is the sharing of the experience itself.

In [5] the authors present a study carried out on the teaching of programming in Portuguese higher education institutions, that support a set of recommendations, such as: practical teaching with feedback on the results, gamification as a way of getting students to collaborate and compete in order to reach a solution, accountability, inverted classrooms, active learning namely based on problems, and assessment by peers.

In [6] is reported the experience with PBL for real challenges, with objectives similar to the ones of this paper. The experience involved three different curricular units and the results obtained also attest to the advantages of active learning, namely based on projects.

In [7–9] two experiments involving PBL are reported, focusing on the same type of development of this paper (mobile applications), but using native technologies (the first two in Kotlin/Java for Android and the last in Swift for iOS).

## 4 Effective Solution Based Learning

The PBL was used by the authors in the curricular unit in question, but for the reasons already presented and the high failure rate of students, it was understood to explore new approaches.

The main goal is to ensure that the learning process is effective for the vast majority of students and that they acquire the necessary skills to build effective solutions to the problems they will have to solve as professionals (speeding up the learning curve). Inherently, approved students with better grades.

Besides, this area of knowledge is extremely active, with constant innovations. It is not enough to teach the present solutions, it is necessary to encourage a proactive attitude towards the search, learning, and use of new solutions. Students should be able to determine and use the most appropriate technological solution for each situation, that is, to look at the problem and build not only effective solutions but with the best technological options.

The strategy adopted was to use the PBL with real problems as already done in other initiatives. However, in this case, students are committed to working towards an effective solution.

This form of learning is based on the assumption that creating an effective solution goes far beyond developing a solution for a project. It is not enough to have a solution that somehow works (but which was made essentially for evaluation purposes), it is necessary to have a minimally complete product (with the minimum set of features necessary to be useful) and a functional product, fully operating under the real conditions of use. The effectiveness of the solution

has to survive the massive adoption by the user community, given the amount of data that may result, the number of accesses/users, and the unforeseen behaviors that result from the inherent diversity of a large population, among many other challenges that result from building solutions for effective use.

It was, however, clear that it is not enough to raise the goals to say that there is a better alternative. There was a need to rethink the entire organization and way of teaching (knowing that the teaching resources would be the same). This work is being done, with continuous improvements, focusing on different aspects of the process. The ones considered fundamental are (for now):

1. The selection of problems/challenges – in the adequacy between what the students must learn and what is necessary to build a solution; the goals, scope, and complexity of the problem; and the dimension and complexity of the solution.
2. The feasibility of providing an effective solution, from the point of view of function, operational, maintenance, and management.
3. Development methodology – it is essential to define a methodology that takes into account the specificities of this context – which is not trivial, considering that most students have their first contact with technology and mobile development in this curricular unit. The development process must be very well defined and supported, with very clear goals for each stage, in order to avoid doing useless work.
4. Organization and management – In the context of the team and in the relationship with teachers. This aspect is closely related to the previous one but it should consider that despite the project being carried out in a team, responsibility would necessarily have to be individual.

In this paper, we address the first two, as they are the ones that are already beginning to have some stability.

### 4.1 Problem selection criteria

To ensure the viability and success of the initiative, it is critical the selection of the problem/challenge. We defined several criteria for that:

- C1: It must be feasible to develop a solution to the problem, using the technologies and skills that should be taught.
- C2: It must be feasible to do the development and validation of the solution within the available time, given that:
  - C2.1: A considerable part of the time is reserved for learning;
  - C2.2: The level of expertise and productivity of students is naturally low.
- C3: The problem goals must be well-identified and delimited (scope).
- C4: The completion of the development and validation mustn't be dependent on non-existent or unavailable equipment, nor on the involvement of third parties. Achieving the objectives should solely and exclusively be dependent on the students.

### 4.2 Transversal requirements

In addition to the defined criteria, there are some transversal non-functional requirements, which result from the context in which all this takes place and from the objectives, namely of the concept of *effective solution*. These are unusual requirements, particularly in an enterprise environment, which reinforce the specificity of the ESBL context.

- R1: The effectiveness of the solutions involves ensuring that it can be used for a considerable period (several years), without technical support. This is because, despite the relevance that the solution may have, the students' obligations end with the completion of the curricular unit, with no obligation to ensure the maintenance of the solution. So everything must be done to ensure that, once the solution is installed and configured, it should work without further technical support from the students.
- R2: Ensure that it is well identified how operational costs will be supported, namely with regard to making the solution available in the cloud and/or in the app stores. As far as possible, development options should take into account the minimization of such costs.
- R3: The problems to be solved must not already have a complete solution in the market, namely by local companies (regional or national). This requirement aims to avoid conflicts with the students' employers, who may see this type of initiative as unfair and disproportionate competition (since everything is done free of charge and within the scope of student training and assessment).

Desirably, the intention is to address problems that are relevant but, for some reason, are not suitable for commercial exploitation. This type of scenario is common when the market size is too small to support the development and maintenance costs. The high development cost charged to a small group of users makes development unfeasible for commercial exploitation. But it creates great opportunities for the use envisaged here.

### 4.3 Case study

There are already two projects implemented under the ESBL. We briefly describe one of them here, the VetApp project, in order to validate the application of the criteria and requirements.

Bragança is the only Portuguese district capital that does not have a public or private emergency veterinary service operating 24/7. The local veterinarians organize among them to provide this service, having a veterinarian on duty on each day of the year. This scale is publicly distributed, namely to public entities such as civil security and the police, but also to common citizens who might need these services. The distribution of days is done annually, normally agreed in December to start operating in January.

If for some reason a veterinarian is not able to accomplish the service (health issues, organization of personal or professional life, ...), he requests a colleague

for the shift exchange. The problem is that these exchanges are not reflected in distributed information. As a result, it is not always possible to contact the veterinarian on duty or we may end up contacting a veterinarian that is not on duty - which would not be critical if the episodes of urgency did not often occur in the middle of the night.

**Verification of selection criteria** What we consider to be the minimum functionalities for the application to be useful are:

- Know who is the veterinarian on duty today;
- Allow user registration, with email confirmation. The registered user becomes a candidate for the veterinarian profile, and an admission request is sent to the Administrator;
- Profile setup (veterinarian);
- Upload a comma-separated values (CSV) file with the shifts distribution (Administrator);
- Access to veterinarian contacts (veterinarian);
- Shift exchange request (veterinarian);
- Acceptance/Rejection of requests for shift exchanges (veterinarian) and admission of veterinarians (Administrator).

The set of functionalities is thus well identified (described briefly here) and results in a perfectly viable project to be carried out in the time available and with the technologies that are intended to be taught, satisfying the criteria C1, C2, and C3. Besides, only the final validation may require the involvement of the veterinarians, satisfying this way criteria C4.

**Verification of transversal requirements** Besides the technologies for multiplatform development, the curricular unit in question is also taught technologies for the implementation of back-ends. With the introduction of ESBL and in order to meet the defined requirements, serverless technologies began to be used, namely Firebase. In this way, the need for server equipment and administration and maintenance resources was avoided (R1). For the intended use, which meets the size of the population, the number of veterinarians, and the number of monthly occurrences, there won't be a relevant cost in hosting the solution on Firebase, satisfying the requirement R2.

Regarding requirement R4, this is a problem that probably only occurs in Bragança and that results from the small population of the region. The main target customer corresponds to less than a dozen veterinarians – developing a commercial application for this market would be very unlikely to be feasible so neither veterinarians in the region can afford a solution, nor will any company develop a solution for it.

## 5 Results

The project was carried out in teams of three students, with four deliveries scheduled (worth 25% of the project grade each):

- Modeling in Figma;
- Isolated React Native components, already with the concept of state and data access from a local file;
- Delivery of integrated components, with navigation and passing parameters between components and screens;
- Final delivery with integration with Firebase (Authentication, Firestore, and Storage) with the most complex functionalities (file upload) and use of more advanced technologies (Context, ...).

There are 193 students enrolled in the course, of which 151 underwent assessment, in a total of 53 teams (not all teams had 3 students). There are thus 21,76% who gave up or did not try to get approved for this curricular unit. After the first evaluation season (it still missing the second evaluation season), the percentage of approved over those evaluated is 63,58%. The average grade of those approved is 12.67 (out of 20 values).

Compared to last year (2021/2022), where the PBL methodology was already applied (with some residual and voluntary teams submitted to the ESBL), there were 169 students enrolled in the course, of which 95 underwent assessment, in a total of 35 teams (not all teams had 3 students). There are thus 43,78% who gave up or did not try to get approved for this curricular unit. After the two initial evaluation seasons, the percentage of approved over those evaluated was 33,68%. The average grade of those approved was 10.6 (out of 20 values).

Compared to the school year of 2020/2021, already using PBL methodology, there were 203 students enrolled in the course, of which 130 underwent assessment, in a total of 48 teams (not all teams had 3 students). There are thus 35,96% who gave up or did not try to get approved for this curricular unit. After the two initial evaluation seasons, the percentage of approved over those evaluated was 86,15%. The average grade of those approved was 12.39 (out of 20 values).

These data are represented in the graph of Figure 1.

There are aspects to highlight in this data. It is important to note that the 2020/2021 school year was somewhat unusual due to SARS-CoV-2, with classes and assessments being done online, which certainly had some influence - which we are not, however, able to quantify. Considering just the past two years, the impact of the ESBL seems somewhat evident. In effective terms, the percentage of approved out of those enrolled went from 19% to almost 50% (with only one evaluation carried out in the last academic year). The difference between those assessed is also considerable, an increase of 40% (from 56% to 78%), which is even more relevant considering that students were warned in good time that the new assessment process (ESBL) would be much more laborious. However, the fact that we can only consider two years and that there are many students who were trying to take this curricular unit for the second, and in some cases, for the third time, may somehow be contaminating the data. We, therefore, understand that it is premature to draw conclusions.

After the conclusion of the project, a survey was carried out among the students to assess their perceptions. They were unaware of the formal existence

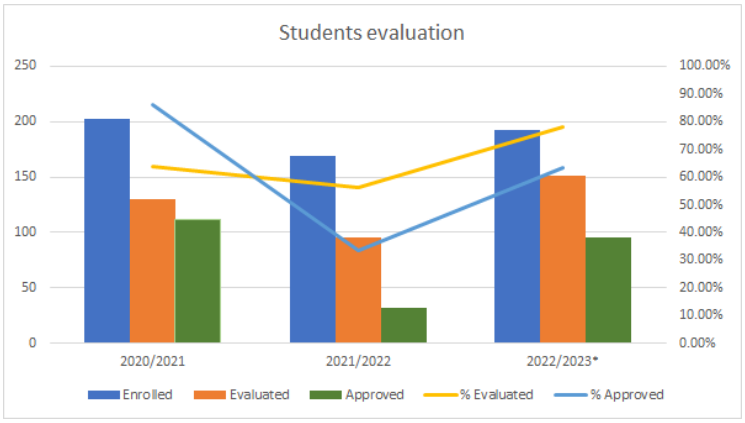


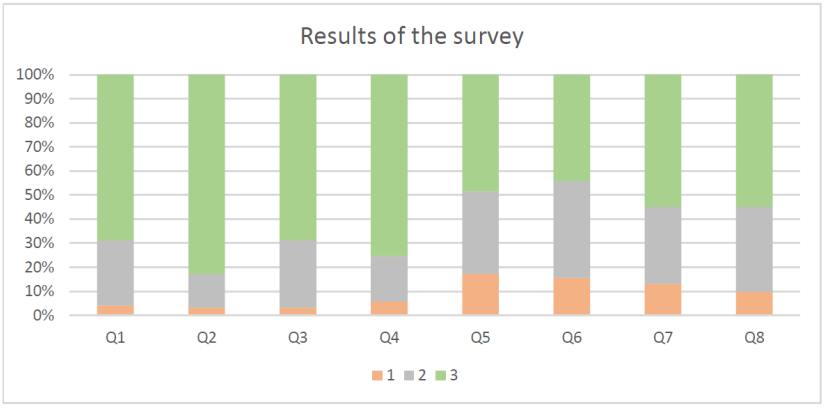

**Fig. 1.** Data from the three years of operation of the curricular unit.

of the ESBL - essentially they were informed about the goals of the project, milestones, and assessment. We obtained 132 responses to the survey. This survey aimed to collect data to evaluate different initiatives. In total, it contains 36 questions, of which we present here eight defined to evaluate the ESBL, they are:

1. I have achieved the training and learning objectives
2. I have made considerable progress in my knowledge and skills
3. The level of demand for this curricular unit is high
4. This curricular unit is a lot of work
5. Make a project contextualized in a challenge proposed by an external entity
6. Present the project to the proposer
7. Deliver (up and running) the project to the proposer
8. Have the active participation of the proposer during the development of the project

The first 4 were answered on a scale of 1 to 3, where 1 means "Disagree" and 3 "Agree". The last 4 were also answered on a scale of 1 to 3, but in which 1 represents "Irrelevant" and 3 is "Relevant". The graph in Figure 2 illustrates these data.

With the exception of questions 5 and 6, all the others deserved more than 50% of Agree/Relevant and the option for Disagree/Irrelevant is small, normally below 10%. In the first four questions, the number of Disagree responses is residual, almost always below 5%. The number of Agree answers to question 2 (*I have made considerable progress in my knowledge and skills*) stands out, with almost 83%. It is interesting that it is in question 5 (*Make a project contextualized in a challenge proposed by an external entity*) that the option for Irrelevant assumes a higher value ( 17%), reinforced by the second highest vote in response to Neutral. On the other hand, of the 4 final questions, the last two are the ones with the fewest responses to Irrelevant.




| | | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Agree | 84 | 101 | 84 | 92 | 59 | 54 | 67 | 67 | Important |
| 2 | Neutral | 33 | 17 | 34 | 23 | 42 | 49 | 39 | 43 | Neutral |
| 1 | Disagree | 5 | 4 | 4 | 7 | 21 | 19 | 16 | 12 | Irrelevant |

**Fig. 2.** Data from the survey.

## 6 Conclusion

In this paper, the authors present what they believe to be a new form of learning (ESBL), already largely supported by a methodology, namely with regard to the eligibility criteria of the problems and the non-functional requirements that must be ensured to obtain an effective solution to the problem at hand.

There is a clear perception that there is still much to be done to better define and put into practice the ESBL methodology. The results, being only for one academic year (not yet fully finalized), do not allow to support conclusions. But in no way can we consider irrelevant the impact in terms of approvals, but mainly in terms of withdrawals.

On the other hand, we have a clear perception that this required a lot of work on the part of students and teachers, and could have had an impact on other activities involved.

### 6.1 Future work

In a general way, it is important to improve the methodology. The adoption of tools and work methods lacks a more careful approach - students do not give due value to this component, which leads them to neglect their use. For example, despite knowing how to use a version controller, they don't do it correctly for teamwork. Something similar happens with communication between the team elements, but also with the project management, in particular in the distribution of tasks. In part, this is perfectly normal, as we are talking about students in the second year of their degree, who still have very little knowledge and lack the expertise to apply the knowledge they have.

We hope to have more data and to have advanced with the ESBL, consolidating the methodology and its practical application.

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