Learning Paths: A New Teaching Strategy with Gamification

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Abstract

Education's primary objective should be to equip students with the skills and knowledge necessary for professional success. However, the current education system often employs a one-size-fits-all approach, treating all students alike and expecting uniform performance. As students progress, their strengths and weaknesses become more apparent, yet they face the same challenges.

This article addresses this issue by challenging the conventional approach in higher education, demonstrating that it can accommodate diverse student needs and aspirations while maintaining academic rigour and incorporating gamification strategies. Within the TechTeach paradigm, a two-path strategy was developed and implemented with 114 students at the University of Minho.

The first path caters to students aiming for satisfactory grades, considering the subject's minimal relevance to their future careers. The second path is designed for aspiring experts in the subject.

The results indicate a high level of student approval, with 90% expressing satisfaction. Additionally, 49.43% of students achieved final grades between 14 and 18, highlighting the effectiveness of tailored learning pathways in meeting diverse student needs and goals.

2012 ACM Subject Classification Information systems → Information retrieval

Keywords and phrases TechTeach, Information Systems, Gamification, Higher Education, Learning Paths, Personalized Learning

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1 Introduction

Higher education students in Europe have significantly increased in recent years [13] - Portugal is not an exception [7] – and professors feel powerless to keep them motivated and focused.

As a professor, I have observed that many students are in classes to do the minimum, and typically, they are conditioning their colleagues who want to learn more about the subject and become experts. This suspicion was easily attested by the surveys answered by the students at the beginning of each class since 2016/17, where only 50% want to learn. The first strategy was to add gamification to the classes, and a new paradigm was created: TechTeach [9]. The results were promising, but professors still found a limitation. They were "forcing" students to learn and do things they were not motivated or ready for because their skills were more suitable to other subjects. Gamification is a strategy, but it is not enough. It is essential to innovate the curricula and make the students learn what they like based on the thresholds defined by the professor. Students also have many alternative knowledge sources, usually not scientifically validated, but they consider enough to learn, moving them away from the classes. The increase in students, verified in parallel with the decrease in professors and the respective diminution of accompanying tasks, puts the teaching systems and future professionals at risk. It is a real problem, and universities must find a new way to address it.

So, a new question was raised: "Why are we requesting the same for all the students if we know that is not positive for anyone?". Instead of creating demotivated professionals, we must demand more from those who want to learn and ensure the minimum knowledge for those with other skills. In the end, all (the students and the professor) win. Analysing the

issue stated, a new teaching strategy based on learning paths was proposed and tested for this proposal. This strategy is part of TeachTeach and splits the students into two groups: Traditional and Advanced. Each student must select a group, and the learning content, projects and grades vary according to the path chosen.

After designing the strategy, a case study was conducted during the 2022/2023 academic year at the University of Minho with Web Programming students in the Information Systems Engineering Course. For the first time, the students could select what they desired to be/have after the subject ended. The narrative was earlier defined and they knew from the beginning what they needed to do to get the expected grade. The narrative was earlier defined, and students knew from the beginning what they needed to do to get the expected grade. Two gamification mechanisms, Cards and Pairs Evaluation, were also used during the process in order to keep the students informed about whether their performance was suitable for the chosen path. The experience, conducted with 140 students, represents an innovative practice in engineering education and was revealed to be a success.

This paper describes the strategy and presents the case study and the first results. It is split into six sections. After briefly introducing the paper, the topics and related work are addressed in section two: background. Then, the material and methods section explains the research process. Section four describes the strategy created, while section five presents the case study deployed. Finally, section six remarks on the research and presents future work.

2 Background

This section presents the main topics of the work and some similar works.

2.1 Learning Paths and Outcomes

Pedagogical innovation is essential to teaching success, and learning paths are a simple way of personalizing learning. Personalizing learning is an alternative to the "one size fits all" learning [2] and refers to approaches that generate multiple learning paths considering the individual differences in learning preferences, goals, abilities, knowledge background, and others [5]. A learning path, embodying curriculum design, comprises a series of structured learning activities aimed at helping users attain predefined learning objectives. Such paths hold significant promise in reshaping professors' approaches to learner support [4, 8]. The Learning paths need to be aligned with Learning outcomes. Learning outcomes are student-centred and describe the measurable skills, knowledge, or values that students should be able to demonstrate after completing a course [16].

2.2 TechTeach and Similar Works

In 2020, Filipe Portela created TechTeach, a new and gamified paradigm to engage students in the classroom [9]. This paradigm combines various digital tools and techniques (e.g. Gamification and project-based learning) to enhance learning results. Since the start, it has been optimized, and new approaches are being created every year, like the creation of assessment exercises using Kahoot! [11]. Motivated by the results, the new strategy presented in this article was improved by the gamification mechanism created at TeachTeach.

Several studies have explored the concept of learning paths. Charzyński discussed educational paths as a form of fieldwork, stressing the necessity of meticulous design and teacher support [3]. In 2021, Ramos [12] introduced a novel learning path model for e-learning systems, leveraging system data to visualize paths and analyze student behaviour. Focused on automatically creating learning paths using open educational resources, a study [15]

showed the techniques and algorithms essential for this process. These studies collectively underscore the significance of meticulous design, data analysis, and practical application in developing and utilising learning paths.

3 Material and Methods

This work is based on the case study method, which allows for exploring a specific occurrence or phenomenon [17]. The process of conducting a case study typically unfolds through various stages, including the development of the design, the collection of data, the analysis of findings, and the interpretation of the results [1]. The specific phases and activities involved in this case study are as follows:

- Design:
  - Understand student's motivation and goals about the subjects
  - Study a new way to increase students' motivation and results
  - Design a new learning strategy that suits students needs
  - Create students' opinion questions to evaluate opinions about the strategy designed
- Implementation:
  - Define the rules and strategy plan
  - Change subject evaluation plan to include strategy designed
  - Choose and implement the gamification mechanism from TechTeach
  - Create a project and put the strategy into practice
- Analysis:
  - Compare students' results with their expectations
  - Evaluate the project results and see the strategy impact
  - Verify students' opinion responses
- Interpretation:
  - Analyse the outcomes to conclude the strategies applied.
  - Evaluating how these results align with the existing learning results of the subject.
  - Exploring the wider implications of this strategy within the context of higher education learning.

The application of case study methodology is justified because it is necessary to study the suitability of creating distinct learning paths while keeping a subject's learning goals intact. This methodology confirmed their applicability to research in real-world settings [6] because it allowed professors to understand students' behaviour and compare it with the achieved results. Regarding the tools, Kahoot was used to receive students' feedback on the subject and their expectations at the beginning, middle, and end. Kahoot [10] was also used for mini-tests. ioEduc [14] was used for gamification mechanisms, such as a card system, quizzes, and peer evaluation.

4 Learning Path Model

This section presents the strategy developed to split teaching into two distinct paths.

Path 1: Basic Knowledge

1. **Focus**: Essential subject knowledge without diving into advanced or recent technologies.
2. **Goal**: Ensure the minimum subject knowledge.

3. **Ideal for**: Students who require an understanding of the subject for general knowledge, not for professional specialization.
4. **Outcome**: Students gain necessary foundational knowledge sufficient for non-specialists.

Path 2: Advanced Exploration

1. **Focus**: In-depth study that includes the latest technologies and trends in the field.
2. **Goal**: Explore the most recent technologies and do work near reality.
3. **Ideal for**: Students aiming to specialize in the subject and pursue it as a career.
4. **Outcome**: Students develop a comprehensive understanding and are well-prepared for professional roles in the field.

In detail,

- On path 1, students are faced with basic knowledge about the subject. They only need to know the essentials and do not need to experiment with the most recent technologies suitable to the study area. This path is usually ideal for students whose subject area is not their professional bet but who need to know the topics.
- Path 2 is advised to students who want to learn more about the subject and prepare to be professionals in that area. These students are typically encouraged to use the most prominent technologies and explore new trends. Ultimately, they will know more about the subject and learn advanced topics essential to becoming a future expert in the area.

Figure 1 represents an example of the learning path, where Classes have a limited time in weeks (100%). It represents, on average:

- Six weeks – Essential Content;
- Two weeks – Multi-content and path chosen;
- Four weeks – Specific Content of the path chosen.

With this strategy, students can balance their efforts and excel in the areas/subjects more suitable to their profile. It will ensure minimum experience in complementary areas and give them time to improve their knowledge in the main area.

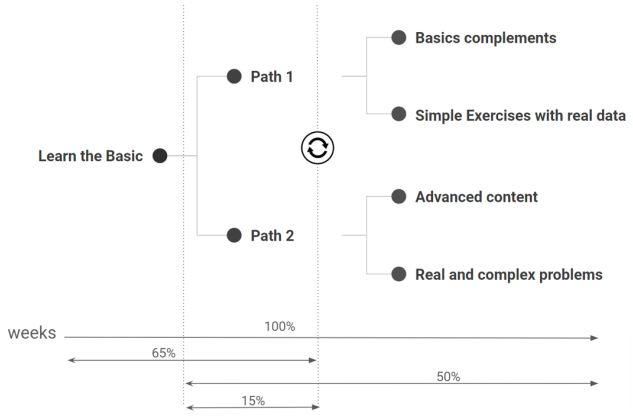


Figure 1 Learning Path Example.

Gamification can be used to motivate students. For example, professors can instigate good performance through badges or points. To best understand what can be used, readers can explore TechTeach.

4.1 Strategy Rules

The strategy allows students to choose one of two learning paths. In practice, it splits the students into two groups. The process is the following:

1. Characterize the learning environment and ask students about their desires, expectations and why they are in the classes;
2. Explain the learning paths narrative to students, their impacts and rules;
3. Show how it works and where it is applied;
4. Create a learning path and agenda for each path;
5. Prepare subject content (matter) according to the paths and ensure that the European Credit Transfer and Accumulation System (ECTS) is kept;
6. Allows students to change the path one time;
7. create a project and add challenges for each path
8. create Gamification methods to valorize those who do more than the expected
9. Grade students according to the path chosen.
10. Ask students for feedback

Students are the only ones responsible for defining their path; professors cannot obligate them to opt for one path or limit their knowledge. For example, if students choose Path 1, they can keep participating in classes directed to Path 2 students. This approach ensures equal opportunity equality following ECT guidelines (time efforts by credits).

Regarding the learning path, some rules must be taken into attention:

(a) Each learning path should be designed according to the learning outcomes.
(b) Validate the effort according to the European Credit Transfer and Accumulation System (ECTS).
(c) Provide clear guidance and resources to support students' progression along the learning path.
(d) Regularly assess and evaluate student progress to ensure alignment with learning objectives.
(e) Offer flexibility to accommodate diverse learning styles and preferences.
(f) Encourage active engagement and participation through interactive learning activities.
(g) Foster collaboration and peer interaction to enhance learning outcomes.

Gamification can be used to achieve some of the goals above.

4.2 Gamification Mechanisms

The gamification model enhances learning, but the narrative must be highlighted initially. Professors can use gamification to

(a) Evaluate student progress;
(b) Promote pairs assessment;
(c) Help students achieve individual goals.

To a better comprehension of how it can be done, section 5 presents the case study.

5 Case Study

This case study regards web programming subject at the University of Minho with 114 active students:

- **Subject**: Web Programming | **Degree**: Engineering and Management of Information System.

- **Academic degree**: Bachelor | **ECTS**: Five.
- **Academic Year**: Third | **Semester**: Second.
- **Weeks**: Fifteen (twelve of contact).
- **Weekly Classes**: One Theoretic (2hours) and One practice (2hours).
- **Main Scientific Area**: Information Systems and Technologies.

5.1 Design

From the beginning (2018) and in the first class, students were asked to explain why they were in classes and the subject relevant to their future. The questions are

1. Why are you here?
   a. I was forced
   b. I want to learn web programming
   c. I have to be otherwise I won't finish the course
   d. I'm in tourist mode
2. Importance of PW for your future
   a. None
   b. Few
   c. Little
   d. Much

Figure 2 presents the results of the questionnaires that were answered from 2018 to 2023 by 478 students.

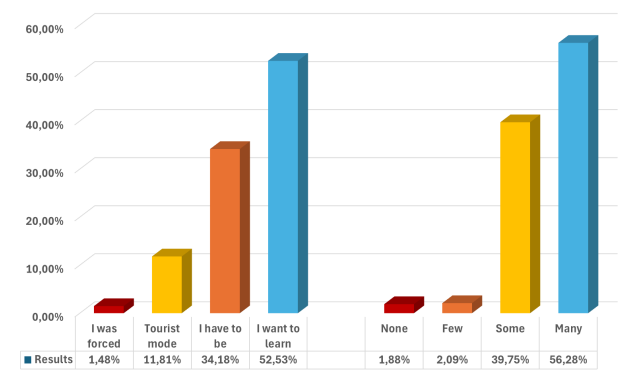


Figure 2 Students opinion at the subject begin.

Analysing figure 2), it is possible to observe that only one-half of students on average want to learn (52,53%) and consider that Web Programming has much relevance to the future (56,28%). This means that around 250 of the 487 students asked were really interested in the classes.

So, *what should we demand the same from all?* The answer is *"we should not"*. We must ensure the same opportunities for all students. and bring responsibility to them. Based on these answers, the learning path was created and implemented for the first time in the curricular year of 2022/2023. At the beginning of the second semester, professors followed the strategy explained in section 4 and defined the following paths: 1. Traditional and 2. expert.

5.2 Implementation

In terms of implementation, the strategy design brings changes to classes and projects. The class content was split according to the path, and a project was created to consider both developments.

Table 1 Units content overview.

ID	Week	Description	Traditional	Expert
U1	1	Web Programming Introduction	✓	✓
	1	– Web 1.0 to Web 4.0	✓	✓
	1	– Cloud Computing	✓	✓
	2	– Client and Server	✓	✓
	2	– Services on the web (IaaS, PaaS, SaaS, FaaS)	✓	✓
U2	2	Client and Server	✓	✓
U3	3	Static Web Pages (HTML)	✓	✓
U4	4	Page Layout	✓	✓
	4	– Web Templating and Design	✓	✓
	4	– Cascade Style Sheets (CSS)	✓	✓
	4	– Syntactically Awesome Style Sheets (SASS)		✓
	4	– Media Queries		✓
U5	5	Frameworks and CMS (client)	✓	✓
	5	– Bootstrap	✓	✓
	11	– CMS and WordPress	✓	✓
	9,10	– Vue.js		✓
U6	6	Dynamic web pages (client)	✓	✓
	6	– JavaScript	✓	✓
	7	– DOM	✓	✓
	8	– Storage, Cookies and Sessions		✓
U7	8	Client-Server Connection		✓
	8	– API and Web Services		✓
	8	– Fetch		✓
U8	11	New Trends and Going Live	✓	✓
U9	2	Web Tools	✓	✓
	2	– AI to coding	✓	✓
	2	– Project tools	✓	✓
U10	5-15	Project	✓	✓

In the beginning, 83 students (72.81%) chose to be specialists, and 31 selected the traditional path. During the weeks, they could change the learning path. The number of specialists at the end was 72 (63.16%).

5.2.1 Subject Plan

The content of the subject and theoretical classes were split into ten units. Table 1 presents the subject organization according to each learning path.

For example, Unit 1 is directed at all students, but Unit 4 has mixed content, where the SaaS and Media Queries content is more suitable for the expert path. Although this organization, classes and content are available to all, independent of their choice. This option does not block the content but clarifies what is or is not essential.

In a weekly plan, U1, U2, U3, U4, U9, and partially (U5 and U6) were taught during the first six weeks. Then, U6 (remaining) and U7 were taught parallelly to both paths. In this period, some content was more suitable for path 2 (expert) than one, but all must participate in the classes. Finally, the remaining U5 was available to all, as Vue.js was "obligated" to path 2, and CMS and WordPress were advisable for path 1. U10 represented the project that started in week five and lasted until the end of classes (week 15).

5.2.2 Assessment Methods

This subject comprises three assessment methods: participation, mini-tests and project. In this first experiment, only participation (quiz bonus for each unit) and project differed in each path. Mini-tests will be experimented with in the future. The final grade was calculated using the formula: *15%*participation(quiz) + 25%*mini-tests + 60% *project*

In terms of participation, classes were not obligatory, but students' attendance was recorded. By attending classes, students can get bonuses and unlock weekly quizzes. Quizzes with bonuses [9] are a gamification strategy that tests the main contents of each unit, prepares students for the mini-tests, and allows students to earn participation points.

Table 2 Project Learning Paths.

Category		Traditional	Expert
Technologies	HTML	✓	✓
	CSS	✓	✓
	JS	✓	✓
	Storage APIs	–	✓
	Vue.js	–	✓
		–	✓
Front-office		Complete	Complete
Back-office		50%	Complete
Maximum Grade		15	20

The project represented a real problem. The statement was: *"Activities4All is an external entity with a group of people who organise events in different areas. This company coordinates group activities and needs a web interface to help manage events. The project includes two aspects of development: traditional and expert. Each group must choose which path to follow. It is important to note that the choice must be made when the group is created and may be changed until the specifications are delivered (Week 9). Once the choice has been formalized, it is impossible to change it, and each group will be evaluated according to their chosen path. The groups comprised 5 (five) elements (+/–1). The functionalities of each element must be divided between the front office (without login) and the back office (with login). Each group must define the tasks per element and include this information in the team's specifications.* Table 2 presents the project rules by learning path being the maximum grade truncated on the defined rules. After selecting the path, groups/students can change it once. They must choose it according to the expected results, as their assessment is limited by the path chosen. A group from the traditional path cannot have more than fifteen, but an expert group can have less than 15 if they don't meet the guidelines.

Regarding project evaluation, there was one control point (week 9) and a final presentation. At the control point, the professor assessed the quality of project development according to the chosen path and proposal. He advised students about development and informed them whether they were on the right path to the defined target. The professor also gave cards to the highlighted students (good and bad).

This learning path strategy also helps students train soft skills and create personalized learning plans. The decision on the path is made in groups; i.e., if some group students want to get a good grade (expert path), they must convince their colleagues, or they will need to choose another group. After creating the group and choosing the path, students write a working contract explaining their project proposal to the professors and firm their commitment. They explain what they will use (technologies), do (functional and non-functional features), and the desired grade at the end. After finishing this starting process, the practical class professor validated the group contract and started a weekly accompanying and validation of working according to the rules (contract) proposed by the students.

5.2.3 Gamification

Gamification mechanisms were used during the classes to help students achieve their goals. Quiz with bonus allowed students to keep the focus and train weekly content. Attendants were randomly selected to have a weekly bonus (double points in the quiz). After the class, they answered multiple questions about the matter taught on ioEduc. In the end, the best performance (without bonus) had a grade of 20, and the other students with a bonus with equal or higher results also had 20, and the remaining had a relative grade.

Professors used card systems to alert/award students to their performance and show whether groups were doing the work expected in their path. The card system is presented in the table 3.

Table 3 Student Evaluation Criteria.

Color	Name	Description
Yellow	First warning	The work performed is below the expected;
Orange	Second warning	The performance is negative, and the student's future at the CUnit is critical;
Red	Student failed	The student did not try to improve their participation. He did not do the minimum acceptable amount, and the level of knowledge is too low, so we cannot do the work.
White	Good Work	The student is working very well, and the professor recognises some extra effort when he is compared to the class.
Blue	Superb Work	The Student is a good example. The commitment level with the CUnit is high, and he deserves to be rewarded.

Each group member also evaluated the project (0-20) and carried out a self-assessment and a hetero-assessment of the group's members. The straight self-assessment was based on N (overall grade) and demonstrated the student's vision regarding their work and the work carried out by the other members of the Group (N, N+1, N+2, N-1, N -2, ...), ensuring that the sum of grades is N. Regarding subject grades, Mini-tests are the only ones not affected by the path until now because they only aim to guarantee that all students have the minimum knowledge required. Class participation gives access to quizzes according to the subject taught, and projects have different goals for each learning path. It also shows that the path chosen does not ensure a grade.

Figure 3 presents an overview of the final grades. In this chart, it is possible to see the grades requested by each group (at the project start and according to the chosen path), the final classification and the difference between the requested and achieved grades. For example, group 11 pointed to 19 but achieved 20 with a difference of one point. Conversely, group 15 did not measure their knowledge/expectations very well and failed (grade <8).

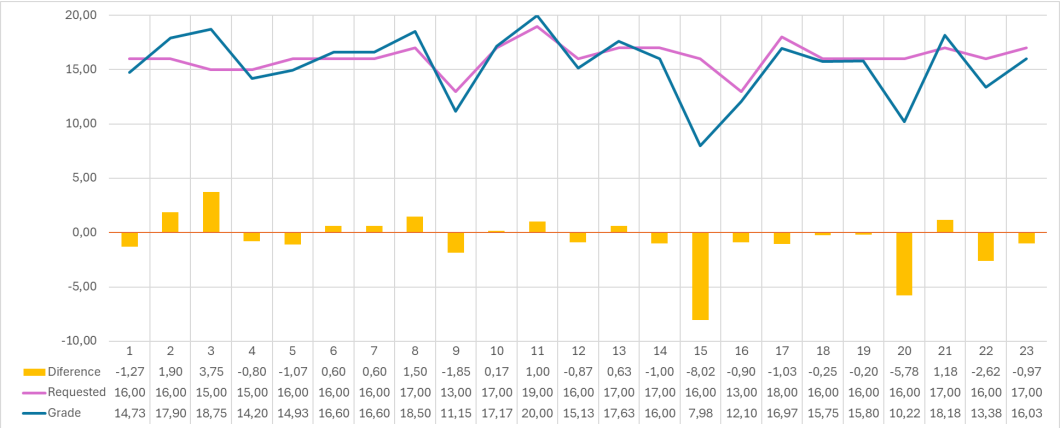


Figure 3 Grades by Project.

5.3 Analysis of the results

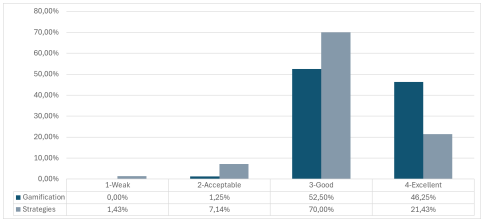
The strategy can be measured in two ways: students' opinions about it and the groups' final grades. Top projects showed significant improvement compared to previous ones, while others performed similarly but with less effort (more suitable to ECTs guidelines). Thus, the strategy effectively helped develop more skilled specialists in Web Programming. However, accurately quantifying this difference is challenging due to changes in the credit value of the Web Programming subject, reduced from 10 ECTS to 5 ECTS, with the introduction of a new curriculum plan in the academic year 2022-23. The results show the relevance of choosing the right path and being honest with the team and professors. The complexity of a subject like web programming requires extra effort to get higher grades. After observing the group's grades, it was easy to see that most groups should select the traditional path.

These observations allowed professors to understand the reality and alert the students in the new academic year(2023/24) to the strategy's effectiveness. Based on this, students were more realistic in the new academic year (2023/24), and the number of experts was reduced to (10/18). However, this subject is running, and the final impact of it cannot be measured (an extended version of the paper will be prepared showing the results).

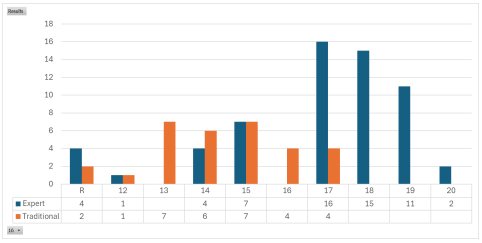
Regarding students' feedback, they were asked several questions, two of which related to the strategy presented in this paper:

1. How do you evaluate the gamification mechanisms?
2. How do you assess the adequacy of strategies and methodologies adopted by the teaching team?

Figure 4a shows the results, where it is possible to observe that the percentage of students that do not consider the gamification mechanism or teaching strategies well-suitable (weak or acceptable) is less than 10%. As shown in figure 4b good students on the traditional path can achieve a final value higher than fifteen, and "expert students" can also have low grades. Only students on the expert path had grades of excellence(higher and equal to heightening). In conclusion, there is an evident separation between the students being 23.50% with grades less than 14 and 25,93% with grades higher or equal to 18.



(a) Subject evaluation.



(b) Students final grades.

Figure 4 Evaluation and Final Grades.

6 Conclusion

This article introduces a novel teaching strategy for Higher Education framed in the TechTeach paradigm. In response to the need for enhanced teaching quality and improved student outcomes, professors developed two distinct learning paths to provide tailored learning experiences and avoid the one-size-fits-all approach. These paths were carefully designed to impact various aspects of the subject program, including exercises and project development.

Each path serves specific objectives: the first path emphasizes foundational understanding, ensuring that students know the subject's fundamental concepts, while the second path is tailored for students aspiring to specialize in the subject and pursue a career in the field. This strategy suggests that 50% of the subject time has the same content for both paths, and 15% has multiple contents (during this time, students can select/change their path). Finally, the last 35% must have specific content according to the designed path.

To validate the effectiveness of the proposed strategy, a case study was conducted during the academic years 2022/2023 in an Engineering course at the University of Minho. The subject chosen for the study was Web Programming, and 114 students participated. Over 15 weeks, students learned the basics and followed their chosen path, doing exercises and completing a project aligned with their learning objectives. Gamification played a relevant role through the use of quiz with bonus and card systems.

Upon evaluation, 90% of the students expressed satisfaction with the strategy, highlighting its positive impact on their learning experience. Notably, the final grades obtained by students were aligned with their chosen paths and corresponding efforts. Students following the second path achieved higher grades on average, reflecting their deeper engagement and commitment to the subject. However, it was observed that students on the second path (exported) who exerted less effort received lower grades than those on the traditional path.

Moving forward, the strategy continues to undergo refinement based on feedback from both professors and students. The 2023/2024 academic year results will be carefully analyzed to optimize the plan further. Additionally, future endeavours will explore implementing this strategy across a broader range of subjects to provide tailored and compelling learning experiences to students across various disciplines.

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