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Bridging Theory and Practice: An Innovative Approach to Android Programming Education through Nutritional Application Development and Problem-Based Learning

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Abstract: This study introduces an innovative Problem-Based Learning (PBL) methodology to enhance the teaching of Android programming, focusing on addressing nutritional challenges. Conducted within the Computer Science degree at the University of Deusto, this research engages third-year students in developing applications aimed at improving access to nutritional knowledge. The novelty of this approach lies in its integration of advanced programming concepts with practical application development, fostering a deeper understanding and engagement among students. The applications enable users to access detailed nutritional information from open-access food databases, catering to individuals with specific dietary constraints. Preliminary results indicate a significant improvement in student engagement and learning outcomes compared to traditional teaching methods, underscoring the potential of this methodology in fostering future researchers and advancing educational practices in computer science. This research contributes to the field by demonstrating the efficacy of combining PBL with application development in enhancing learning experiences and outcomes in programming education. Our findings not only contribute valuable insights into the unique challenges and motivators associated with Android programming but also pave the way for tailored educational strategies that can optimize the learning experience in this domain.

Keywords: action research; active learning computing education; cross-disciplinary skills; engagement; nutrition; project-based learning (PBL)

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1. Introduction

The evolution of educational methodologies is pivotal in cultivating the future researchers and innovators of tomorrow [1,2], necessitating a relentless pursuit of innovative and effective teaching approaches [3–5]. This investigation is at the forefront of educational innovation, introducing a novel Problem-Based Learning (PBL) methodology to instruct Android programming, merging it with practical and socially relevant challenges in human nutrition.

Conducted within the structured environment of the programming lectures at the University of Deusto, this study involves third-year students enrolled in the Computer Science degree. The setting and the demographic are crucial in understanding the impact and the applicability of the introduced methodology, which focuses on an immersive learning experience. The proposed methodology challenges students to be active participants in their learning journey, developing Android applications that address pressing nutritional problems, a growing concern in today's health-conscious society [6]. This methodology not only deepens the comprehension of intricate programming concepts but also nurtures critical and reflective thinking and practical problem-solving skills, elements that are indispensable for budding researchers [7,8]. As argued in these investigations, it is necessary to establish a challenging learning atmosphere that enables students to acquire new knowledge, skills, and competencies. To this aim, alternatives for increasing student engagement far beyond traditional and inflexible teaching approaches must be offered in the classroom.

The applications conceptualized and developed during this research endeavor are designed to augment access to nutritional knowledge. They specialize in delivering detailed, user-specific nutritional information sourced from reliable, open-access food databases. This feature is a boon for individuals with specialized dietary needs, enabling them to make informed dietary choices, a need that is increasingly becoming paramount in our diverse societies [9]. The initial outcomes of this research are promising and indicative of a substantial enhancement in student engagement and learning outcomes, a significant stride compared to the outcomes of conventional, more rigid teaching methodologies. These encouraging findings accentuate the transformative potential and the versatility of amalgamating PBL with practical application development in the realm of programming education.

By intertwining advanced programming with real-world application development, this study makes a contribution to the evolving landscape of educational methodologies in computer science. It underscores the imperative of incorporating practical application and real-world problem-solving in the learning process, a strategy that is corroborated by several studies investigating meaningful learning [1,10]. The primary objective of this investigation is to methodically measure and analyze student engagement levels in Android programming, particularly within the initial stages of their developmental journey. While numerous studies have explored the broader realm of programming engagement [11], our research stands distinct in its sharp focus on Android-specific development. Our findings not only contribute valuable insights into the unique challenges and motivators associated with Android programming for beginners but also pave the way for tailored educational strategies that can optimize the learning experience in this domain. This study, therefore, serves as both a diagnostic tool and a foundation for future pedagogical advancements in the field of Android development education.

In the application of the methodology, students work all semester long in an active style, trying to investigate or respond to complex challenges. As a result, PBL is a challenge not only for students but also for lecturers as it moves away from the more traditional teaching practices. PBL implies a change of roles, work methodology, and evaluation in which students actively form teams and face complex challenges. Moreover, PBL invites students to identify what they should learn, to become involved in the search for information, to define strategies to be used, and to agree on common solutions.

2. Detailed Context of the Problem

The contemporary landscape of education is witnessing a paradigm shift, with an increasing emphasis on methodologies that transcend traditional lecture-based learning. In this transformative era, the integration of Problem-Based Learning (PBL) [12] in teaching Android programming emerges as a revolutionary approach, addressing the multifaceted challenges in human nutrition.

The problem's context is deeply rooted in the growing complexities of nutritional needs and the escalating demand for personalized dietary information [9]. Individuals with specific dietary constraints often grapple with the inherent difficulty of accessing appropriate and reliable nutritional information, a challenge that is accentuated by the plethora of unverified and generic information available [13]. Problem-Based Learning (PBL) thrives on real-world challenges that resonate with students, prompting them to apply theoretical knowledge in practical scenarios. In this study, the choice of a problem centered around healthy nutrition is particularly selected. Nutrition is a universal concern, affecting every individual regardless of background or profession. By anchoring the PBL experience in such a universally relevant issue, the study ensures immediate engagement and relevance for the students. The intricacies of nutrition, with its myriad of variables like calories, macronutrients, and micronutrients, provide a complex problem space ideal for computer science solutions. This complexity pushes students to think critically, design algorithms meticulously, and develop applications that are both functional and user-friendly. The immediate societal implications of their solutions—potentially aiding individuals in making healthier dietary choices—add an additional layer of motivation and responsibility, making the learning experience deeply personal and impactful.

The popularity of gluten-free and vegan diets has notably increased, with a 67% rise in gluten-free diets in the United States since 2013 [14], and a growing adoption of vegan diets, particularly in the Western world [15]. Table 1 summarizes the global prevalence of vegetarian, vegan, and gluten-free diets, highlighting the increasing trend and varying adoption across continents. The data indicates higher adherence to vegetarian diets in South America and Asia, a significant preference for vegan diets in South America, and a common observance of gluten-free diets in Asia, Oceania, and Europe. Overall, Table 1 illustrates the extensive scope of nutritional care challenges, suggesting that PBL can effectively address this widespread social issue by engaging students in real-world problem-solving. Thus, applications developed are envisioned to be of use for the vast area of nutritional information by making use of open access high-quality food databases. The challenge is designed to automate food selection based on individual dietary constraints, thereby empowering users to make informed and health-conscious decisions.

The significance of addressing this problem is multifold. It not only contributes to the advancement of educational methodologies in computer science but also has profound implications in the field of human nutrition and public health. By fostering a learning environment that encourages the development of practical and socially relevant applications, this study aims to cultivate a generation of researchers equipped with the skills and knowledge to address relevant social challenges. Adhering to a restricted diet is inherently challenging, necessitating careful planning to meet daily nutrient requirements [9]. Suboptimal diets can diminish disease protection and pose health risks, especially for those with mandatory restrictions due to allergies. Given the rise in dietary restrictions, providing efficient tools to navigate food choices is crucial, as many products lack detailed ingredient lists [13].

Table 1. Mean percentage population sticking to three well-known restricted diets (vegetarian, vegan, and gluten-free) by continent.

Continent	Vegetarian Mean %	Vegan Mean %	Gluten-Free Mean %	Sources
Africa	NA	NA	0.5	[16]
Asia	11.4	3.85	0.8	[16,17]
Europe	5.9	1.9	0.8	[16,18,19]
North America	8.7	2.65	0.5	[16,20,21]
Oceania	4	2	0.8	[16,22,23]
South America	14.9	9	0.6	[16,24,25]

Although the nutritional challenge offers a unique blend of complexity and societal relevance, the underlying principles of this PBL approach are highly generalizable to other areas within computer science. The essence of PBL is to immerse students in real-world problems, pushing them to apply, adapt, and extend their theoretical knowledge. Whether it is developing AI algorithms for traffic management, creating cybersecurity solutions for emerging threats, or designing user interfaces for e-commerce platforms, the core tenets remain the same: identify a genuine problem, understand its intricacies, and devise a solution using computer science principles. The nutritional challenge serves as a testament to the adaptability of PBL, demonstrating that with the right problem selection, students can be engaged, motivated, and equipped with skills that transcend the classroom, preparing them for diverse challenges in the ever-evolving landscape of computer science.

Research Questions (RQ)

This investigation seeks to explore the intersection of innovative educational methodologies and practical application development, focusing on the domain of Android programming and its implications in human nutrition. The research is guided by the following refined questions:

(RQ1) *Innovative Learning Impact*: How does the integration of Problem-Based Learning (PBL) within Android programming lectures enhance the learning experiences and outcomes of computer science students, compared to traditional instructional methods?

(RQ2) *Application Development Engagement:* To what extent does the development of Android applications addressing real-world nutritional challenges engage students and foster a deeper understanding of advanced programming concepts?

(RQ3) *Practical Implications and Accessibility:* How do the developed applications improve access to reliable and personalized nutritional information, and what are the implications of such improvements on individuals with specific dietary needs?

(RQ4) *Educational Significance:* How does the incorporation of real-world challenges in teaching methodologies contribute to the advancement of educational practices in computer science, and what is its broader impact on cultivating future researchers?

(RQ5) *Comparative Analysis*: How do the learning outcomes and student engagement levels compare between the courses implementing the PBL methodology and those following classical approaches in teaching Android programming?

Each of these questions is designed to delve into different facets of the research, exploring the impact of the innovative methodology on learning experiences, the engagement and understanding fostered by application development, the practical implications of the applications developed, and the broader significance of integrating real-world challenges in educational methodologies. By addressing these questions, this study aims to shed light on the transformative potential of integrating innovative educational approaches with practical application development in enhancing learning and addressing societal challenges.

The intended principal outcome is to show evidence of the application of PBL within lectures on computer programming and how it can be combined with application development in order to increase motivation in the classroom. PBL has the students learn, organize, and solve challenges while students themselves remain responsible for their own investigation and process of work. We propose to follow a series of milestones that incorporate agile development during the semester. Through this work, we aim to show that the use of PBL combined with application construction provides reliable evidence that a much deeper understanding of computer programming is attained by students participating in the challenge. The investigation also intends to evaluate if application development in Android poses sufficient engagement for students. In terms of technology and accessibility, the Google Android and Apple iOS markets have exponentially grown, reaching nearly 98% of the consumer market. As the relevance people currently put on healthy nutrition and the expansion of mobile applications increases, it is one of our aims to determine to what extent nutrition applications can be employed to set up challenging learning contexts.

3. Description of the PBL Method

To immerse students in a realistic software development project and to address the outlined research questions, this study adopts the method delineated by Rohde et al. [6], focusing on key performance indicators that assess the usability of food tracking applications from a user-centric perspective. This method is pivotal in evaluating the developed applications' efficacy in providing reliable and user-friendly nutritional information.

The cited study considers many of the popular food-tracking applications based on traditional behavior theory components. We also take into account [26,27] for our internal evaluation, which identified several aspects that should be offered by a food tracking application in order to be useful: (i) whether the application offers general knowledge and detailed information, (ii) whether the application implements cognitive strategies (perceived benefits, perceived barriers, perceived risks and efficacy), (iii) whether the application implements behavior strategies (monitoring capacity, realistic goal setting, time management, stimulus control, self-reward, social support, modeling or vicarious learning, relapse prevention, emotion-focused strategies, stress management, and negative affect management), and (iv), whether the application offers therapeutic interventions (skill-building, increasing knowledge, and motivational readiness). The list of relevant items identified in the mentioned categories is extensive, and so we summarize it in the following comprehensible table (Table 2). The table enumerates the most relevant aspects from the previously cited categories, which will be used to evaluate the applications developed by student teams. At the end of the semester, the applications developed by students are meticulously evaluated based on this comprehensive list of relevant items identified in the aforementioned categories. These items serve as the benchmark to assess whether the applications developed by student teams meet the desired outcomes in terms of usability, reliability, and user engagement.

Table 2. Main characteristics for nutritional application evaluation considering behavioral strategies.

Level	Category of Interaction	Description
1	Information or guidelines	Application provides primarily general information or data that are not individualized.
2	Assessment	Application asks the user for current behavioral practices or use of strategies.
3	Feedback	Application comments on the user's current behavioral practices or strategies.
4	General assistance	Application offers non individualized suggestions about how to change or apply a strategy that are not responses to any assessment (Item 2) and do not require feedback (Item 3)
5	Individually tailored assistance	Application has suggestions about how to change or apply a strategy specifically tailored to the user

The proposed method also integrates traditional behavior theory components, emphasizing cognitive and behavioral strategies in order to to develop applications that are not only informative but also conducive to promoting healthy dietary habits [26,27]. The applications are designed to offer general knowledge and detailed information and implement various strategies such as monitoring capacity, realistic goal setting, time management, stimulus control, self-reward, social support, modeling or vicarious learning, relapse prevention, emotion-focused strategies, stress management, and negative affect management.

4. Learning Materials

Student teams were tasked with developing applications that consult multiple food databases to retrieve detailed nutrient lists from food products, introducing the primary innovation of the challenge. This involves integrating various micro-services of open-access food databases, accessible via barcode scanning, a feature prevalent in health-related applications [26]. This interface facilitates instant access to extensive food product data and is a compelling functionality for students. Post-search applications are designed to display detailed information or filter items based on user preferences, alerting users to items matching their indicated preferences.

The investigation utilized several nutrient databases, including Open Food Facts, a collaborative project providing comprehensive information on global food products, updated daily under the Open Database License. FoodData Central, USDA's integrated system, offers extensive nutrient and food component data accessible via API or local download, allowing third-party applications to analyze multiple food items. EDAMAN provides distinct API functionalities, including the Nutrition Analysis API and the Food and Grocery Database API, offering complete nutritional analysis and detailed nutrition facts for products. Lastly, EuroFIR collects detailed food product information for multiple countries, offering access to a wide range of item descriptions through its Food Explorer API.

Application Use Cases

Applications developed by teams were required to offer a set of diverse functionalities, including food product searches and detailed listing of nutrients. We also made an attempt to have students focus development on usability by implementing an engaging user interface based on a simple, ready-to-use experience. Some applications developed by students require users to log in by creating a personalized profile (see Figure 1 (left)) in which to define their specific conditions or restrictions (see Figure 1 (right)); this is how the application is aware of not allowed nutrients and based on these personal preferences the application sets its alarms when food searches are performed (see Figure 2 (left)).

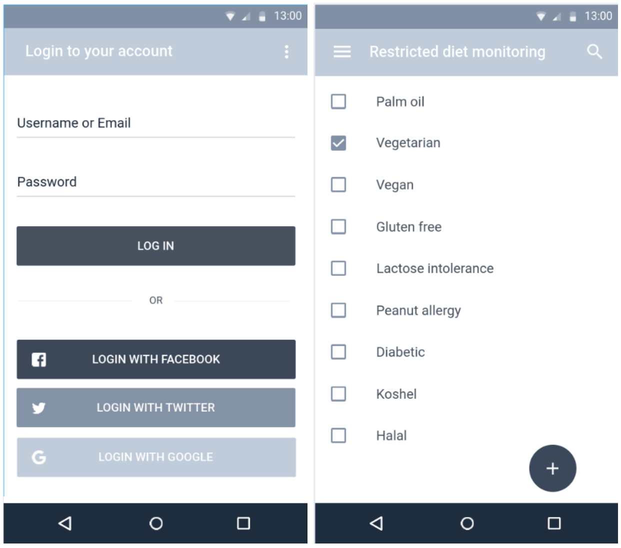

Figure 1. Login screen (**left**) and restricted diet monitoring screen (**right**).

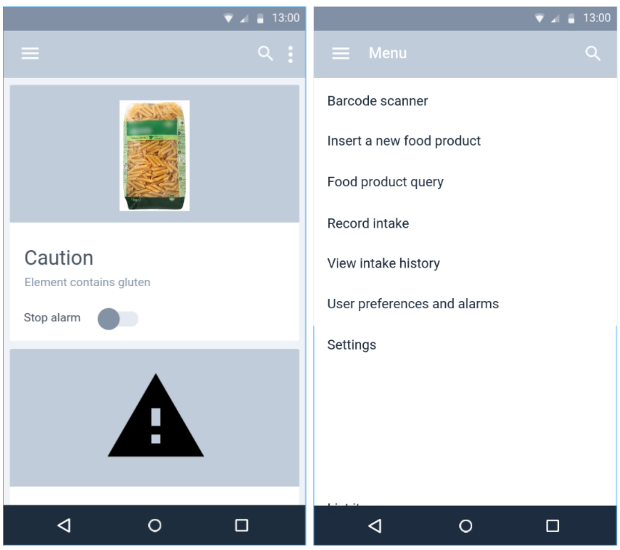

Figure 2. Alarm functionality (**left**) and main menu of the application (**right**).

Teams also implemented key functional aspects such as product analysis and detailed search (application main menu can be seen in Figure 2 (right)). Search is performed through queries, and queries contain some data that uniquely identifies an existing food product. Once the query is done and a product is found, the application shows a detailed list of nutrients for the given item (see Figure 3 (left)). The detailed list of the nutrients is expected to be sufficient in order to identify if a product is suitable or not for consumption. In case the product is identified as unsuitable for consumption, the application shows the reason why it has been discarded.

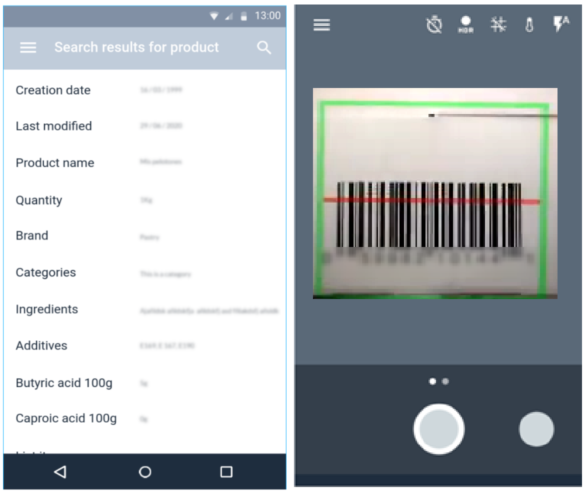

Figure 3. Food product search result (**left**) and barcode scanning functionality (**right**).

The majority of the students conducted the search process combining two different approaches: on the one hand, through the scanning of barcodes (see Figure 3 (right)). This process is performed by making use of the smartphone's camera service. In this case, the user is asked to point the camera to the food packaging label where the barcode is usually placed, and the application automatically detects the label, launches a query to the database systems, and displays its nutrients. On the other hand, students also implemented product searches by matching names. Finally, student teams were also requested to consider saving a logging history of consumed food products; this functionality can be used to keep track of nutritional factors, such as consumed energy, fat, saturated fat, carbohydrates, sugars, proteins, and salt (see Figure 4 (left)), and is also able to produce simple non-personalized feedback according to predefined health statistics (see Figure 4 (right)).

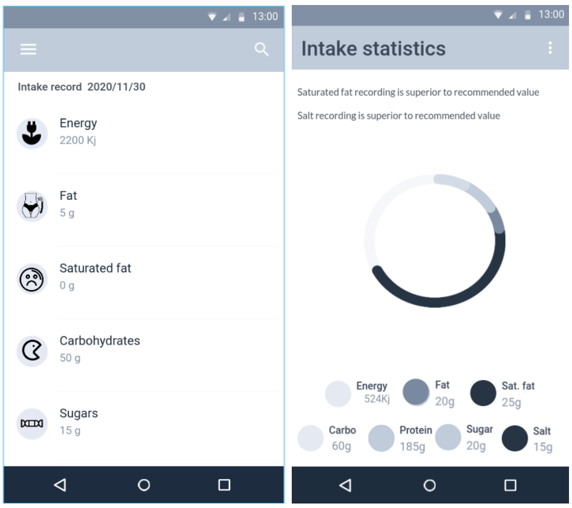

Figure 4. Food product search result (**left**) and barcode scanning functionality (**right**).

5. Participants and Workflow

Programming is a third-year first semester course in the Department of Informatic, Electronic, and Communication Technologies at the University of Deusto (San Sebastian faculty, Spain). The course introduces advanced elements of Java and Android programming to students, such as memory usage, inheritance, polymorphism, lambda expression, advanced data structures, thread management, and code optimization. The course provides a deep understanding of what actually advanced programming is, and it is based on a classical chalk-and-talk-style.

The course comprises four contact hours per week and an additional tutoring hour. It has traditionally been delivered in a face-to-face descriptive format using a chalk-and-talk style, aided by some laboratory programming assignments. The learning outcomes of the course are that upon successful completion of the course, students should be able to (i) identify, analyze, and define the significant elements of a computer program; (ii) use one's own experience and criteria in the analysis of requisites and design and build up a more effective and efficient solution; (iii) understand the advanced principles of inheritance and use it to design more solid and reusable architectures; (iv) formulate and describe application requisites using Unified Modelling Language diagrams and identify and apply an appropriate solving technique; and (v) define and apply good design patterns to solve different problems considered difficult. Thus, individuals who graduate in computer engineering are able to apply their knowledge to solve application development problems in different areas related to information technologies, providing the most appropriate solutions in each case. The main contribution of the subject of Computer Programming to the degree in computer engineering is the resolution of application development problems and the analysis and design of requisites based on existing requirements and applying the precise criteria of effectiveness, efficiency, costs, and benefits involved.

The topic of computer programming is an important field within computer science engineering. It is of great importance that computer engineers understand how applications are developed and how such processes are carried out in development teams. Students in computer science can deal with moderately complex design architectures; nevertheless, measuring real assessment of developed applications through questionnaires is not currently performed.

Regarding the workflow, we describe the working timelines of student teams to illustrate the main steps adopted and how these integrate within the semester course. Within the agile development framework, each student team commits to delivering incremental value to the end-product. Initially, student teams create the *Product Backlog*, a prioritized list of features, enhancements, and fixes that form the product's roadmap. After discussing the roadmap with the lecturer, the cycle begins with Sprint, Planning, a brainstorming session where teams select items from the Product Backlog to address in the next sprint. A sprint is a designated time period during which students' development progress is evaluated. In this period, they collaboratively set the scope, breaking down backlog items into manageable tasks. Throughout the sprint, teams engage in periodic meetings or stand-ups with both group members and the lecturer. In these concise, time-boxed meetings, members update on their current status, future plans, and any challenges, ensuring transparency and rapid problem-solving. The practice comprised three sprints or evaluation periods, each ending with a Sprint Review where teams present their completed work to the lecturer. This is an opportunity to assess achievements, obtain feedback, and plan for the next stages. For ongoing enhancement, teams participate in the Sprint Retrospective meetings, a session to reflect on successes, challenges, and areas for improvement in upcoming sprints. Figure 5 summarizes the described workflow.

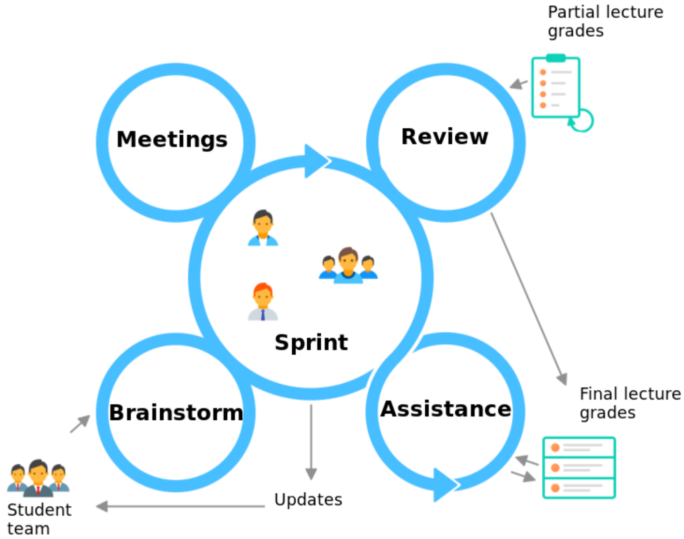

Figure 5. Student team workflow diagram. Student teams realized a total of three sprints in which they developed functionalities for their applications. Every sprint begins with a brainstorming session and ends with a review meeting in which the work is evaluated. During the working timeline, there were several scheduled meetings accompanied by the assistance of the lecturer.

6. Research Tools

The research tools employed in this study are meticulously selected to ensure the robustness and reliability of the research outcomes. These tools are pivotal in evaluating the developed applications and assessing the impact of the innovative teaching methodology on student engagement and learning outcomes. In order to measure the students' learning achievements, we employ a variety of resources that are directly mapped to the original research questions, which are: (i) the internal conclusions of the student teams, which correspond to the intra-evaluation reports of the students extracted from assignments (RQ1, RQ2, and RQ4), (ii) impressions of the lecturers throughout the semester (RQ1, RQ2, RQ4, and RQ5), (iii) assessment of developed applications (RQ3), (iv) final lecture grades (RQ1 and RQ5), and (v) student engagement evaluation reports collected using questionnaires by the University of Deusto (RQ1, RQ4, and RQ5).

6.1. Learning Achievements within Groups

The aim of the proposed problem has been non-trivial as it involved a full front-end and back-end implementation of a nutritional Android application. On the one hand, working in front-end development, students are able to focus on creating the user interface and experience. Some positive aspects noted by students involving front-end development include being able to see the resulting product immediately. Front-end developers can see the changes they make to an application in real-time, which can be rewarding and motivating. Front-end development also implies working with the latest technologies, which requires keeping up-to-date with the latest technologies and trends. On the other hand, working in back-end development means that students are able to focus on the server-side of an application. Some positive aspects noted by students involve creating robust and scalable applications, which requires a deep understanding of architecture and design patterns. Students also remarked that working in the back-end of a nutritional application implied working closely with data, which is actually one of the principal learning materials of the investigation. Overall, the results obtained from internal student reports revealed that the PBL remained as challenging as rewarding.

6.2. Impressions of the Lecturer throughout the Semester

The development of the project has been positively evaluated by the authors because of the following principal outcomes: (i) it generates a high interest as students face a social challenge involving nutrition; (ii) it is useful to tackle different specific, generic, and transversal competences from the computer science degree; (iii) students practice Android theory lectures observed in class, and act as facilitators of the knowledge to other students and, as a consequence, teams construct knowledge as the team evolves; and, (iv) students simulate an agile development unit that must apply according to some software development methodology. This adds extra motivation to the work as teams follow the very same rules they will eventually have in industry. It is noteworthy to mention that discussions within the development teams also favor communication between students and the lecturer.

6.3. Assessment of Developed Applications

In order to evaluate the usefulness of the applications developed, we conducted a user case study with 18 volunteers from superior courses from the Computer Science degree and let them experiment with the applications for one month. After this time, volunteers were asked to fill in a form regarding the characteristics addressed in Table 2. For each aspect under evaluation, we asked volunteers to rate characteristics on a scale between 1 and 10. Figure 6 shows the results of the user study.

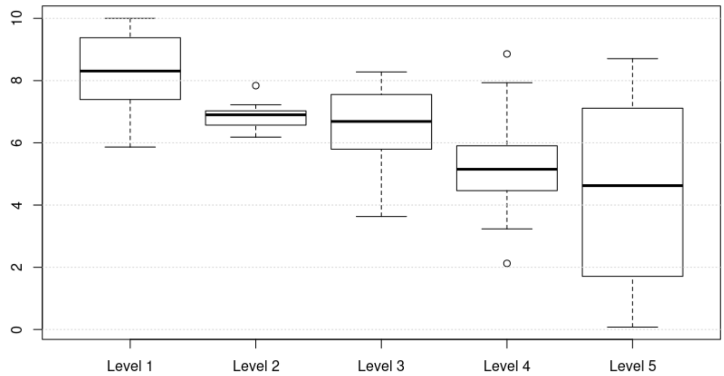

Figure 6. Box-plot results of the user study concerning the five levels of evaluation analyzed in Table 2.

According to the results, the best-valued features are related to level one, level two, and level three. It seems that by accessing open access databases, the applications are able to provide general information so as to satisfy the needs of users in a great manner. In the same way, the user preference-based information extraction form is also well-reviewed and is able to handle behavioral practices for users. Nutritional information graphics and simple visualizations are also valued, even though this feature has been evaluated to a lower extent. On the contrary, levels four and five are the worst-valued characteristics of the applications. As expected, even though the application handles alarms when restricted food products are found on searches, the capacity of the application as regards general or individually tailored assistance is limited.

6.4. Final Lecture Grades

Measuring student engagement through the analysis of final grades is a common practice in the state of the art within educational research [1]. In order to assert that the instructional strategy involving PBL is an effective approach to help students learn subjects, we compare distinct student performances across two consecutive academic courses in which the programming lecture has been taught following the same schedule and evaluation criteria but different learning processes. This way, we show results for one of the courses that has been taught involving traditional Android practices (2020/2021), while the second course has been taught with the PBL methodology (2021/2022).

The distribution of students alongside obtained statistics for grades is shown in Table 3 for the academic courses concerning 2020/2021 and 2021/2022. Assuming an underlying normal distribution on the grades indicated by a Shapiro–Wilk test of normality, we conducted a one-sample Wilcoxon signed-rank non-parametric test to check whether the performance mean values were significantly different. Test results indicate that student average performance has been higher when PBL activities have been carried out with regard to classical approaches (V = 26, p-value < 0.05). Significantly better student performance suggests that a higher level of engagement has been attained in the academic course 2021/2022, in which students were challenged with the development of a nutritional application.

Table 3. Distribution of students and statistics for grades attained by students.

Course	Method	Count	Mean	Std	Min	Max	25%	Median	75%
2020/2021	Classic	24	6.65	1.55	2	10	5.40	6.50	8.15
2021/2022	PBL	27	7.75	0.85	3	10	6.25	7.75	8.8

In addition to the final grades obtained by students, we also include the Student Engagement Evaluation Reports (SEER) that the University of Deusto collects every academic year with regard to all subjects collected by means of questionnaires designed and offered to students by third-party professionals. SEER questionnaires include a total of 30 items of evaluation regarding the impressions of students with regard to engagement intervention. SEER questionnaires are completely anonymous to lecturers, for which they can only access the final mean results. The items under evaluation fold into one of the following categories: (i) design and planning of the resource materials, (ii) learning management and capabilities of the activities, (iii) tutoring and evaluation capabilities, (iv) evaluation of the lecture, (v) review and improvement, (vi) collegiality and (vii) competence of the lecturer. Figure 7 shows the comparative results for the questionnaires in the 2020/2021 and 2021/2022 academic courses for the mentioned set of evaluation categories. As shown in the figure, almost all evaluation items are superior in the academic year 2021/2022, in which the student grades are also statistically higher.

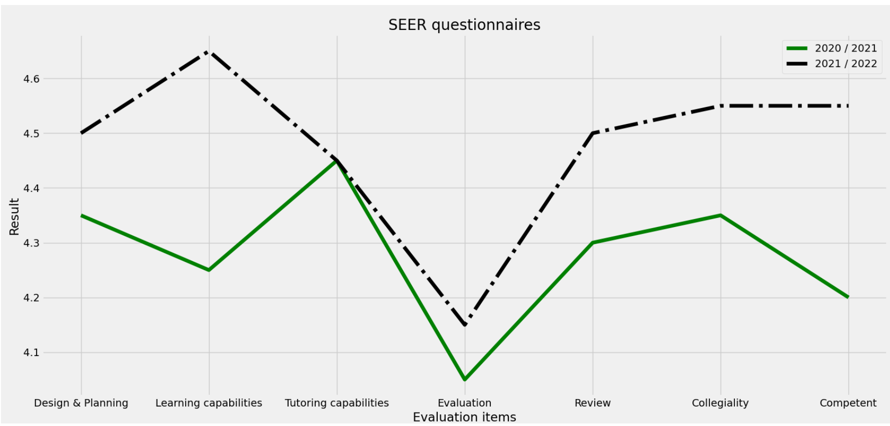

Figure 7. Student Engagement Evaluation Reports (SEER).

7. Conclusions

Leveraging the unprecedented growth in mobile applications due to rapid advancements in smartphone capabilities, this study explores the transformative potential of integrating innovative educational methodologies with practical application development. It unfolds within the programming lectures at the University of Deusto, involving students in the third academic course of the Computer Science degree, and employs Problem-Based

Learning (PBL) as a pivotal educational methodology to enhance the learning experience in programming. The focus is on developing socially innovative smartphone applications, with students tasked with creating applications aimed at improving access to knowledge in human nutrition. The nutritional challenge serves as a dynamic context for the learning process, leading students through the development process to harness detailed nutrient information from open-access food databases. The applications developed are meticulously designed to automate food selection for diets with constraints, presenting non-trivial solutions that assist individuals in adhering to restricted diets.

We now summarize the main contributions of the present work according to the initial research questions addressed.

(RQ1) **Innovative Learning Impact:** The core of our investigation revolves around the development of socially innovative smartphone applications. Students were entrusted with the task of creating applications to bolster access to knowledge in human nutrition. This nutritional challenge, far from being a mere academic exercise, provided a dynamic context for learning, guiding students to extract detailed nutrient information from open-access food databases. These applications, meticulously crafted, offer automated solutions for diet constraints, aiding individuals with restricted dietary needs. Internal conclusions of the students' teams, impressions of the lecturers throughout the semester, final lecture grades, and student engagement evaluation reports not only expose that innovative outcomes have been significant but also the practice served to enhance the learning experience.

(RQ2) **Application Development Engagement**: The rising interest in nutritional applications was leveraged to boost student engagement and instill a sense of responsibility. This strategy not only simplified access to esteemed nutritional databases but also spurred introspective thinking about the societal ramifications of the applications they developed. Internal conclusions of the students' teams, impressions of the lecturers throughout the semester, and student engagement evaluation reports confirm that addressing a real-world nutritional challenge highly engaged student performance.

(RQ3) **Practical Implications and Accessibility**: The applications, while technically sound, were also designed with a keen eye on usability and societal impact. They serve as tools that not only provide information but also influence dietary choices, especially for those with specific dietary restrictions. An in-depth state-of-the-art analysis was carried out to curate a list of different levels of evaluation as regards applications with behavioral strategies. The assessment through usability questionnaires curated from relevant evaluation items revealed that developed applications improved access to knowledge in reliable and personalized nutritional information.

(RQ4) **Educational Significance**: Our approach, which marries real-world challenges with academic learning, has manifested positive outcomes in terms of student engagement throughout the semester. It presents a holistic platform where theoretical constructs are tested against real-world developer challenges, enriching the educational journey by weaving in societal challenges. Internal conclusions of the students' teams, impressions of the lecturers throughout the semester, and student engagement evaluation reports revealed that the incorporation of real-world challenges in teaching methodologies contributes to the advancement of educational practices in computer science.

(RQ5) **Comparative Analysis**: Final evaluation results confirmed the significance of the PBL approach. There was a noticeable uptick in student outcomes and a richer learning experience compared to preceding courses.

All in all, this innovative approach of intertwining real-world problems with learning has shown positive evidence of more active student implication on the semester, offering a multifaceted platform where theoretical knowledge meets real-world developer challenges. It also enriches the educational experience by integrating societal challenges, molding students into mindful developers who are cognizant of the broader impacts of their applications. The methodology has not only sparked high interest and engagement but has also highlighted the importance of fostering a balanced learning environment that aligns technical proficiency with societal awareness.

8. Discussion

In the continually advancing field of computer science education, pedagogical strategies must evolve to accommodate the dynamic nature of technology and the distinct challenges it presents. The existing literature, while vast, often casts a wide net—endeavoring to tackle the overarching principles of teaching methodologies without necessarily zoning in on niche areas of concern. This investigation has tried to shed light on a specialized foray into areas such as the realm of Android programming education and its associated pedagogical nuances.

Positioning itself at the intersection of computer science education and Android development, our study addresses a crucial gap in the state of the art. As computer science educators often grapple with specific instructional challenges—ranging from students' varying prior knowledge to the ever-changing development environments—our research provides invaluable insights into one of the contemporary scenarios: fostering engagement in Android programming. By systematically exploring the unique hurdles and motivators in this domain, this investigation serves as a beacon for educators confronted with particular pedagogical situations. In a time when generic solutions often fall short, our study carves a niche by offering tailored strategies and considerations specifically for the Android development educational space.

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