NOURISHING THE FUTURE: INNOVATION TO CLOSE THE GAPS IN NUTRITION APPS FOR A HEALTHIER UNIVERSITY LIFESTYLE

Gabriela Vieira Pinto

Dissertation

Master's in Innovation and Technological Entrepreneurship

Supervised by

Professor Doutor Manuel Firmino Torres

2024

Honor Pledge

I declare that the present topic proposal for my master's dissertation is my own and has not been used before in any other course or curricular unit of any institution. References to other writers strictly comply with the principles of attribution and are adequately indicated in the text and the bibliographical references, according to the referencing rules. I am aware that plagiarism and self-plagiarism constitute an academic offence.

Acknowledgement

Firstly, I want to express my most sincere gratitude to my dissertation advisor, Professor Dr. Manuel Firmino Torres, whose wisdom, encouragement, and occasional eyebrow raises at my overly ambitious ideas have been invaluable.

To my family, I thank you the most for being the rock-solid foundation upon which I have built my dreams. Your unconditional support, whether it was listening to my enthusiastic rants about business ideas or giving a heartwarming hug during moments of doubt, has been the fuel that pushed me forward. I promise to finally explain what innovation and technological entrepreneurship mean at the dinner table.

To my friends, thank you for understanding when I disappeared into the abyss of research and writing. Thanks for the endless support, laughs, and late-night brainstorming sessions, no matter how absurd.

To my classmates and the entire academic community, thank you for nurturing an environment of teamwork, innovation, and intellectual curiosity. Your insights and discussions have widened my perspective and enhanced my knowledge.

Lastly, to the one reading this, keep in mind that the journey is just as valuable as the destination. Embrace the challenges, celebrate the victories, and never underestimate the power of a good laugh amidst the chaos.

Abstract

This dissertation investigates the potential of innovative nutrition applications to address dietary challenges faced by university students. A thorough literature review reveals gaps in current nutrition apps, specifically their ability to meet specific students' needs. The research question investigates whether innovation can bridge these gaps to promote healthier eating habits. This study argues that tailored nutrition apps can substantially enhance students' dietary habits. The study uses a methodology approach with diverse techniques of qualitative and quantitative types to gather information. A design science methodology guides the development to address the identified gaps. The research sample comprises university students and nutritionists, ensuring a thorough grasp of the user's needs and expert perspectives. The findings show that existing nutrition apps often fail to interest students consistently due to a lack of personalised features and practical instruction. The proposed innovations focus on user-centric design, including personalised nutritional guidance, simple meal planning, and real-time feedback systems. This study highlights the potential of customised nutrition apps to improve dietary habits and well-being. The conclusions emphasise the need to combine technology and human-centred design in building efficient nutrition interventions for university students. This study aims to contribute to the current debate on using technological innovation to improve nutrition outcomes among university students. However, more research is needed to continue increasing the impact of these benefits on university students.

Keywords: nutrition apps, university students, innovation, dietary habits

Index

Index of Tables

Index of Figures

1. Introduction

Universities are at the forefront of innovation and technology in the constant evolution of knowledge, which makes university students the perfect target for the research we are about to go through. Over the years, the nutritional habits of university students have become increasingly concerning as they face challenges in nourishing a healthy lifestyle. With overbearing daily course schedules and late-night study sessions, students choose convenience over nutritive foods and seek fast and often unhealthy meal options.

It is no surprise that eating habits and lack of access to information on nutrition impact the overall health and well-being of students and affect academic development in the long term. Research has shown that "students who are under academic, social, and emotional stress may develop unhealthy eating habits and emotional eating as coping strategies (Tamang, 2023, para. 15). The pressure to excel at university, combined with diverse stress factors, leads students to choose comfort foods, which affects their academic performance.

Research shows a balanced diet can lead to higher grades and improved memory, concentration, and energy (American Dining Creations [ADC], n.d.-a; Baerren, 2023). However, for most students, going to university implies changes in their nutritional choices, especially since most leave their households to pursue their studies (ADC, n.d.-a). The shift from homemade cooking to the cafeteria or fast-food alternatives can be challenging, as students may lack the ability or knowledge to make healthy choices in a new and unfamiliar setting. They often opt for easier, faster, and more affordable meals, which are not sustainable for their bodies and minds and affect their academic performance (ADC, n.d.-a; Tamang, 2023). However, most know that food affects their studying capabilities, so why do they still struggle to eat healthily throughout university?

> Students try to balance taking classes, going to work, exercising, and maintaining a social life daily, which means their days are filled with many time-consuming activities. … College attendees may even want to eat healthier, but the structure of their lives prohibits it or makes it much harder to eat the right foods (ADC, n.d-b, para. 1-3).

Managing numerous obligations leaves little time for meal prepping, resulting in students relying on prompt solutions with low nutritional value. Although they often have good intentions, an overwhelming university schedule makes it hard for them to prioritise their desire to eat healthy food.

Nowadays, university students have easy access to mobile applications. Numerous apps on the market offer nutritional advice and guidance, along with tracking of food intake. Quantitative research about mobile app usage among young adults shows that 90% use apps daily (Amaral et al., 2023). Nutrition apps are cheaper and more convenient than consulting an expert or doctor, so they are a great tool to motivate students (Bell, 2022). This author stresses that these apps offer a variety of approaches, from food tracking to food quality and general guidance. He also argues that nutritional apps are recommended since they allow us to learn about nutrients and adapt meals. Although these apps offer benefits for their users, they may need to recognise the needs of tailored users, such as students, creating a gap that needs to be analysed and providing an opportunity in the market for customised solutions.

Studies show that creating nutrition apps for specific niches has been proven to increase the usage of the apps and improve health and behaviour toward eating habits (Salas et al., 2023). Therefore, finding innovative solutions to bridge the gap in nutrition applications and develop healthier food relations and behaviours among university students is crucial. For that, it is essential to understand the needs of the students and analyse existing gaps, issues, and opportunities in this field of study.

1.1. Motivation

This dissertation is part of the Master in Innovation and Technological Entrepreneurship and will focus on innovation, technology, and the social importance of a business. By interacting with students and experts in the nutrition area, we want to understand the unsolved needs of young academics and the point of view of professionals. The current apps make it hard for students to stay hooked and maintain a healthy diet; thus, we want to find out the gap in the apps and what innovation could help solve it.

This curiosity emerged from working on a few projects through the master's and learning how a more human approach can make a difference in the market. As an IT graduate working on a personal project to help spread knowledge in the nutrition field to younger generations, this seemed the perfect opportunity to gather more information on user needs regarding applications, specifically in nutrition.

As nutrition is vital for humans overall, writing this dissertation is an opportunity to empathise with the users' experiences with nutrition apps and understand their perspectives, hoping that it will help further research in the nutrition field.

1.2. Research Question

According to this context, this research aims to answer the following question: Can innovation solve the gap in nutrition applications for university students to develop a healthier food relation and behaviour?

To retrieve proof and data for this research, we used a survey to obtain student app usage patterns and interviews with nutrition professionals. We adapted a design science framework by Hevner et al. (2004).

1.3. Objectives

There is ongoing research about the gaps in nutrition apps and how they can contribute to a healthier lifestyle. While it is a growing concern, further research is still needed to amend this problem.

Our objective is to search for the gaps in nutritional apps and define how innovation could contribute to closing them to enhance usage for university students, and with that, some specific objectives emerge:

- Determine the gaps that leave a new opportunity for innovation.
- Identify the unmet needs of university students on nutrition applications.
- Identify the current innovation behind the nutrition apps.
- Define a set of innovations to fill the gaps in nutrition apps.

1.4. Structure of this Dissertation

This research is divided into diverse sections. We started by introducing this dissertation's main topic and objectives. We will proceed with the literature review and its contribution to our research based on existing knowledge, then move over to the research methodology, presenting our research question and the study's design. We proceed to present the results of the survey and interviews, followed by the interpretation of the findings. We will finalise this dissertation with a conclusion of our research, its limitations and future research. In the upcoming chapters, we aim to contribute to an academic research process in hopes that it will allow the continuation of solving this problem in practice.

2. Literature Review

Now that we have overviewed the objectives and the structure of this research, this section will present a review of past research, summarising the main concepts and critically analysing the selected literature, grouping it into categories, notably nutrition apps, eating habits and food knowledge among university students.

2.1. Research Outline

We searched for articles on the Web of Science and on Scopus, filtering by articles published from 2016 to 2024 and by enriched cited references, using the keywords 'nutrition AND apps AND innovation AND university students'. We found 87 articles after excluding the duplicates, of which we read 50 abstracts and arranged them by importance to the research. We then read 25 articles and analysed them to seek the existing gap in nutrition apps and how to help university students maintain a healthy lifestyle using nutrition apps. The main concepts and future research of the chosen articles are further explained in Table 1.

Table 1. Literature Review (Source: Compiled by the author)

Authors & Year	Main Concepts	Future Research
(Abdelhafez et al., 2020)	They aimed to identify food habits and barriers that hinder healthy eating habits among university students. It is essential to break the eating habits of university students to spread knowledge.	More research is needed to determine the best approach to tackle barriers to adhering to a healthy diet.
(Asberg et al., 2024)	They wanted to understand behaviour change in university students exposed to digital interventions targeting multiple lifestyle behaviours.	Interview participants on their individual and technological preferences.
(Baungaard et al., 2023)	They used a mixed-methods approach to find the gap in the existing literature regarding sustainable diets (SDs) and the role of nutrition students in sustainability.	Although there is interest and proof to sustain the need for change, there must be more proof to check if nutrition students are adequately trained for a sustainable nutrition system.

Authors & Year	Main Concepts	Future Research
	They analysed the level of familiarity with SDs among nutrition students and explored the barriers that stop students from using SDs.	
(Brown et al., 2021)	They tested a dual-process model comprising behavioural-directed and opposing behaviour habits in middle school and university students.	More investigation of habit models is required to inform researchers about whether and how habit measures could be improved.
(Chen et al., 2018)	They used a framework to guide dietitians on including apps in the Nutrition Care Process (NCP) to enhance patient education and counselling.	Dietitians should recommend apps alongside counselling to promote self-monitoring of goals, boost adherence, and allow bidirectional data exchange.
(Coman & Checeches, 2024)	They analysed university students' perceptions of food literacy. They used a qualitative inductive approach to explore the results from a "learning-by-doing" model towards university students.	Further investigation of university students' food literacy using evidence-based educational models is recommended. Future studies should verify that baseline data about the parties' understanding of nutrition exists for more substantial results.
(Dute et al., 2016)	Using theoretical methods, research on how applications can contribute to a healthier lifestyle among students.	The effectiveness and long-term usage of apps, plus finding other options to handle health issues through apps, especially regarding social characteristics, needs further study.
(Estrada-Araoz & Mamani-Roque, 2023)	Research on knowledge about nutrition in nursing university students and their role in the passing of food education in the future.	Enhance the curriculum and incorporate nutrition courses to improve comprehension of the topic.
(Evans & Clarke, 2019)	The case study describes the creation of a nutrition app designed for low-income households and	It would be interesting to see behaviour change from a long-term perspective.

Authors & Year	Main Concepts	Future Research
	how to adapt the design for a better user experience.	
(Franco et al., 2016)	Comparison of well-known nutrition application features and analysis of the used technologies for nutritional review	Room for improvement regarding tailored nutrition, including individualised feedback, nutrition plans, or food literacy.
(García-Mata & Celis-Moscoso, 2023)	They measured food literacy among university students. Their research involves university students who focus on gaining healthy eating habits and the developers of nutrition apps. Theory of planned behaviour applied to food literacy	The sample is particular, so verifying the scale among larger student samples is an opportunity to develop future research.
(Guiné et al., 2023a)	They used a scale to evaluate and test food literacy among university students. The main factor is food literacy, split into three sub-factors: literacy about the nutritional composition of foods, literacy about labelling and food choices, and literacy about healthy eating practices.	Food literacy among university students should be further explored, as it is a crucial niche in promoting food knowledge. The food literacy scale could be used to compare responses from different countries.
(Guiné et al., 2023b)	Define if sociodemographic and academic factors intervene with food knowledge and explore how lifestyle affects food literacy in university students.	Implement some interventions to improve food literacy among university students.
(Ho et al., 2023)	Mitigating errors on Formosa FoodApp to check reliability as a self-reporting nutrition tool and improve nutrition intake data. (university students recruited for research)	They recommend extending the accuracy of self-reported nutrition apps to other age groups, such as kids and older people.
(Hoge et al., 2022)	They studied health literacy and perception of the front-of-package labels (FOPL) among university students.	Further verification is needed from research testing FOPL in food-purchasing settings.

Authors & Year	Main Concepts	Future Research
(Jabour et al., 2021)	It is about analysing the usage rate of mobile health apps among university students and determining the barriers that discourage using those apps.	Use focus groups to understand better the student's perceptions and the aspects that affect their adoption rate.
(König et al., 2018)	They explored the adoption process of diet and fitness apps, the behavioural factors, and the decision-making choices at different adoption stages.	Further research is needed to explore the correlation between fitness app adoption and choosing phase.
(McNamara et al., 2021)	They qualitatively analysed how the nutrition literacy domains (functional, interactive, and critical) influence university students' food choices.	Assess food literacy and design programs to enhance the dietary behaviours of university students. Quantitative analysis of university students' nutrition literacy.
(Molina-Recio et al., 2020)	It is knowing and listening to everyone involved in designing and using nutrition apps. They present a theoretical model that explains the gap in nutrition apps and all involved parties (the Great GApp).	Mobile apps are promising because they help transmit knowledge about eating habits and offer motivation for behavioural shifts. Whenever the Great GApp emerges, it can lead to a lack of commitment and reduce the possibility of enhancing the quality of health.
(Montagni et al., 2018)	University students share their perceptions of using mobile health applications.	Deeper study on the benefit of internet and mobile-based tools for health.
(Mostafazadeh et al., 2024)	They evaluated the connection between food literacy and eating behaviours among nursing students.	Future research should analyse the level of nutritional knowledge among nursing students.
(Mummah et al., 2017)	It is about testing vegetable consumption through application intervention in overweight adults and important motivation factors to include in apps.	Further research is needed to evaluate the impact of technologies on people with low vegetable intake who did not participate in the weight loss experiment.

Authors & Year	Main Concepts	Future Research
(Rana et al., 2021)	They compare the dietary intake of university students in age-matched samples.	Future research should assess nutritional variations among students with and without all-you-can-eat settings.
(Sogari et al., 2018)	Eating habits among university students and what factors lead or hinder them from eating healthy. Usage of an ecological model to promote healthy behaviour.	More accuracy in the link between nutrition and health needs to be explored. Collect a bigger sample size, particularly when considering socio-cultural differences. Assess if tailor-made interventions are efficient in altering behaviours towards a healthy lifestyle.
(Tavakoli et al., 2016)	Health Belief Model (HBM) and its capability to impact university students' understanding, attitude, and behaviour.	Future research should opt for a standardised nutrition scale.

After analysing the selected twenty-five articles, we found that several authors expressed their points of view regarding nutrition apps, food literacy, and university students' eating patterns, providing diverse standpoints. For this research, the above-described articles were grouped into "Nutrition Apps - A Modern Nutrition Solution?" and "Eating Habits and Food Knowledge Among University Students". Once these perspectives are discussed, we will close the literature review by identifying and discussing the gap.

2.2. Nutrition Apps - A Modern Nutrition Solution for University Students?

Since university students are more involved in technology and innovation, using applications could help enhance their eating habits and food literacy. They are a large target audience for nutrition apps, but they value their utility, simplicity and accessibility when considering one (Jabour et al., 2021; Montagni et al., 2018). A wide range of nutrition applications already exist in the market, used to track caloric intake, offer customised suggestions, and encourage self-monitoring to boost users' healthier nutrition habits.

Montagni et al. (2018) noticed that despite the promising apps in the market (c.f. 5.2.), most university students continue to lean on websites over apps for information, revealing a gap in the adoption and continuous usage of these apps. The apps lack a user-centred approach

and design that fully meets the users' needs, often resulting in them uninstalling the apps. According to Asberg et al. (2024) and Rana et al. (2021), university students' adherence to nutrition apps could be boosted by linking functions to personal needs.

An attractive design and usability system can enhance those apps' user experience and retention rate. Evans and Clarke (2019) proved the importance of formative research in developing a nutrition application by adapting to a user-centred approach. They showed how constantly innovating can boost an application in terms of solving the specific needs of users by giving them a voice in the development and adapting to their needs.

Apart from users, Molina-Recio et al. (2020) studied the importance of different roles in developing nutrition apps to fill the gap. They call it the Great GApp if the technological companies, end-users, healthcare providers and academic entities are not considered during the application design. Each party brings a unique perspective to ensure users' adherence to the app. Companies are trained to develop apps but lack the nutritional knowledge that healthcare providers have, and academic entities provide the current innovations to support the apps in question.

All those entities have the common objective of trying to build an app that meets the users' needs. However, the user undergoes different behavioural stages when dealing with a health-related app. König et al. (2018) highlight the need to analyse the different stages and identify five using the Precaution Adoption Process Model: unengaged, determined to act, decided not to act, active, and disengaged. The stage a user is in depends solely on their behaviour.

Mummah et al. (2017) found that behavioural drivers such as fun, pleasure, surprise, and social and cultural contrast have been proven effective in growing healthy habits. Keeping those behavioural drivers aligned with the users' preferences is undoubtedly a promising asset to keep them engaged. Although, according to Chen et al. (2018), nutritionists and health practitioners argue that users can manage their food intake effectively with features like food journals, barcode readers, and nutritional information, the viability of these apps relies on user consistency, knowledge, and willpower.

2.3. Eating Habits and Food Literacy Among University Students

Eating behaviour and food literacy are two key aspects that university students need to obtain a healthy and sustainable diet. Researchers have been studying the lack of food literacy

among university students as it is still a growing concern, but improving eating habits is more complex than it seems.

University students tend to restrict themselves to certain foods when they strive for a specific goal, such as weight loss. However, this approach does not give them sustainable, healthy eating behaviour. The development of such behaviours is closely linked to students' food knowledge, which goes beyond the ability to organise, plan, choose, and cook meals that meet nutritional needs and personal taste preferences (Coman & Checeches, 2024; Guiné et al., 2023a). The trigger to that behaviour is knowing how to use food literacy when preparing their meals.

Coman and Checeches (2024) described food literacy as acquiring, processing, and understanding nutritional information to make proper dietary choices. The poorer their food literacy is, the more likely they will be unhealthy. However, it is easier said than done since healthy choices can be challenging even with the right mindset. As they studied the theory of planned behaviour applied to food literacy, García-Mata and Celis-Moscoso (2023) noticed how essential factors like attitude, social pressure, behaviour control, intention and behaviour are. Besides those factors, their constant academic challenges are bound to impact their food choices.

Lack of time, expensive costs of healthy ingredients, and easy access to fast food are among some challenges that Abdelhafez et al. (2020) and Sogari et al. (2018) noticed among university students when trying to maintain a healthy diet. Even with this, students try to balance studies, social life, and healthy nutritional habits. However, they often become overwhelmed and opt to adapt to their environment instead of finding a sustainable relationship to food.

McNamara et al. (2021) and Sogari et al. (2018) state that factors like broader nutrition education, food preparation, and uplifting social surroundings sustain healthier nutrition habits. Since they are in a learning environment, incorporating sustainable diets and food literacy in university courses could increase adherence to healthier habits (Baungaard et al., 2023; Guiné et al., 2023b; Mostafazadeh et al., 2024). Be it through workshops, webinars or peer learning, using the connection at university to learn more about nutrition would be an asset. The university's resourcefulness could also promote an innovative, more sustainable approach to encouraging healthier eating among students, such as nutrition apps.

2.4. Conclusions

The reviewed literature highlights the importance of food literacy and eating behaviours among university students to maintain a sustainable and healthy diet. The challenge of using food literacy to improve nutritional behaviour is still concerning since even the right mindset can struggle to make healthy choices. As García-Mata and Celis-Moscoso (2023) stated, behavioural factors like attitude, social pressure, behaviour control, intention and behaviour itself are what influence the choices made by university students regarding food. Plus, there are significant barriers to eating well as a university student, such as restricting schedules, costs, and close exposure to nutritionally poor meal alternatives.

Researchers have been trying to tackle these challenges over the years by analysing applications and how they can contribute to the problems students are facing. Although the apps still need to be analysed over the upcoming years to find further approaches to meet the users' needs, research has already identified some gaps. One of the gaps is the lack of user-centred approaches and design, which leads to students uninstalling the apps since they value usability and simplicity. To understand the users' needs, giving them a voice and ensuring they receive accurate data by including app developers, nutrition professionals, and academic entities is essential (Molina-Recio et al., 2020).

Another identified gap is the user's unpredictable behaviour. Although Mummah et al. (2017) have shown that some behavioural drivers like fun, pleasure, surprise, and social and cultural drivers effectively grow healthy habits, this gap is rather arduous since it relies on user consistency, knowledge and willpower.

In short, the knowledge obtained in the literature helped us identify and understand the gaps in nutrition apps. It allowed us to apply that knowledge in the chosen methodology framework, presented in the next section.

3. Methodology

Now that we have reviewed past research and identified the gaps in nutrition apps, this section will present the research design, the tools used to collect data, the sample used, and the data analysis methods.

3.1. Design Science Methodology

Remembering our research question: Can innovation solve the gap in nutrition applications for university students to develop a healthier food relation and behaviour?

Since this study intends to discover if the gap in nutrition applications can be solved through the growing innovation in the field, we will use the design science approach to execute the research.

We adapted the framework in Figure 1 from Design Science in Information Systems (IS) Research (Hevner et al., 2004). The model is divided into three parts, starting with the IS Research section, which includes the building and evaluation processes. The second part is the Environment, including people and technology; the third is the Knowledge Base, including foundations and methodologies. The Environment and Knowledge Base helps assess and refine the Research, which is applied to the Environment and added to the Knowledge Base.

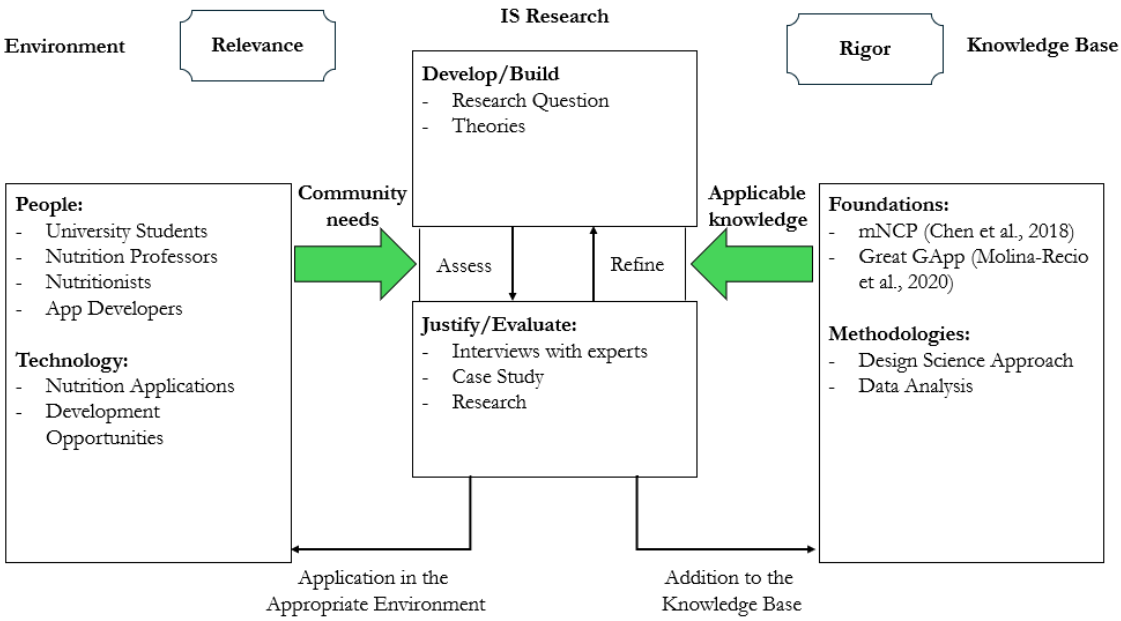

Figure 1. Design Science Framework (Adapted from Hevner et al., 2004)

As illustrated in Figure 1, the people involved in the industry are university students, nutrition professors, nutritionists, and app developers, while the technology includes nutrition apps and innovation opportunities. This research aims to meet that community's needs by using existing research knowledge and input of gathered data through surveys and interviews.

3.2. Data Collection and Analysis

We are using a mixed-methods approach, having, on the one hand, used a survey to gather insights from university students and, on the other hand, interviews to understand the perspective of nutritionists. We sent the survey to university students from Portugal and Luxembourg using dynamic e-mails and student forums aimed at general university students and nutrition students. As for the nutritionists, we aimed for one nutritionist from the university services and one external nutritionist. We gathered the data from the survey anonymously and recorded the interviews with the permission of both interviewees.

We organised and cleaned the data in an Excel sheet for the responses to the survey and retrieved the relevant statistics. Regarding the data from the interviews, we transcribed and translated the responses we received from Portuguese to English and analysed them while grouping the answers.

3.3. Conclusions

As already said, this research aims to apply the knowledge base to assess the involved parties' needs, particularly university students. To gather further data, we created a survey for university students and interviewed two nutrition professionals. The questionnaires and results are presented in the following section.

4. Results

Now that we have described the methods used to obtain our data, we will proceed with the data gathered from the university students and the nutritionists.

4.1. University Students Survey

To gather insights from university students, we created a survey with Google Forms, dividing it into three sections. Table 2 presents the set of questions for each section and the corresponding question type.

Table 2. University Students Nutrition App Experience Survey

Section	Questions	Type
General information	Gender	Multiple choice
	Age Range	Multiple choice
	Country	Short answer
	Study Level	Multiple choice
	Study Field	Short answer
	During university, I live	Multiple choice
	When it comes to cooking	Multiple choice
Nutrition vs University	Do you struggle to maintain a healthy diet while being busy at university?	Multiple choice
	What describes you best? (On a scale of 1 "I eat mostly junk food" to 5 "I eat mostly homemade food")	Likert scale
	How does eating junk food affect you academically?	Checkboxes
	What factors usually lead to poor eating choices?	Checkboxes
	How would you describe your relationship with food? (On a scale of 1 being bad to 5 being excellent)	Likert scale

Section	Questions	Type
	How well-informed are you about food and its nutrients?	Multiple choice
	Take this space to share additional thoughts or experiences regarding this topic!	Long answer
Nutrition Apps	How frequently do you use nutrition apps to track your dietary habits?	Multiple choice
	What reason led you to download a nutrition app?	Checkboxes
	Have you ever stopped using a nutrition app? If yes, what was the reason?	Long answer
	How satisfied are you with the available nutrition apps? (On a scale of 1 "not satisfied at all" to 5 "very satisfied")	Likert scale
	Can you name the nutrition app(s) you use(d) and how they meet your needs?	Long answer
	Do you agree with the following statement: "Nutrition apps adequately address the needs and preferences of university students."	Multiple choice
	In your opinion, what features are crucial in nutrition apps to benefit university students?	Long answer
	Would you use a nutrition app incorporating personalised recommendations tailored to your university lifestyle?	Multiple choice
	Which of the following options would you use as a university student?	Checkboxes
	Any final comments or insights?	Long answer

These questions allow us to retrieve the students' perspectives regarding nutrition and nutrition applications and even spot patterns according to characteristics.

4.2. Data From the Survey

The survey was directed to ninety-five university students in Portugal and Luxembourg and included a mix of open and multiple-choice questions, as shown in Table 2. The quantitative data from the responses to the several questions are presented in Table 3 and Figures 2 to 12 below.

Table 3. General Characteristics of Survey Participants

Section	Characteristics	n	%
Gender	Female	57	60
	Male	38	40
Age Range	18-21	26	27.4
	22-25	43	45.3
	26-29	13	13.7
	30+	13	13.7
Country	Portugal	60	63.2
	Luxembourg	27	28.4
	Other	8	8.4
Study Level	Bachelor	48	50.5
	Master	41	43.2
	PhD or Doctorate	6	6.3
Study Field	IT/Computer Science	14	14.7
	Nutrition	11	10.5
	Entrepreneurship	9	9.5
	Engineering	9	9.5
	Other	52	55.8
During university, I live	alone	14	14.7
	with my partner	8	8.4

Section	Characteristics	n	%
	with my family	51	53.7
	with other students	22	23.2
When it comes to cooking	I have my own kitchen	50	52.6
	I share a kitchen	36	37.9
	I do not cook	9	9.5

Note. $N = 95$.

The above-listed data represents survey participants' sociodemographic and general characteristics regarding their university cooking setting. Having that, we will present charts to visualise more survey findings. In Figure 2, you can see a graphical representation of how women and men respond to their struggle to maintain a healthy diet during academic stress.

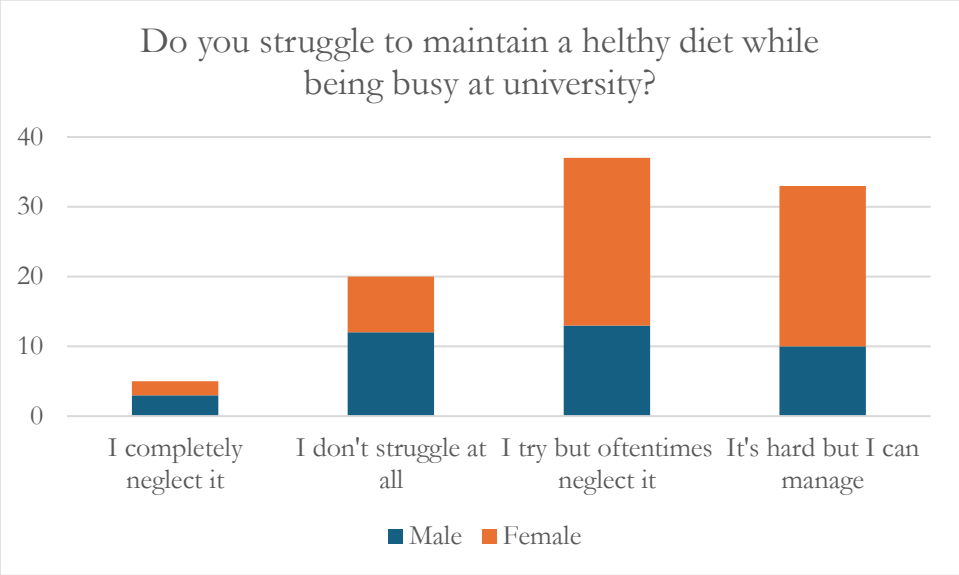

Figure 2. Gender Comparison on Struggle to Maintain a Healthy Diet

In Figure 3 below, you can see a graphical representation of gender tendency to homemade and junk food.

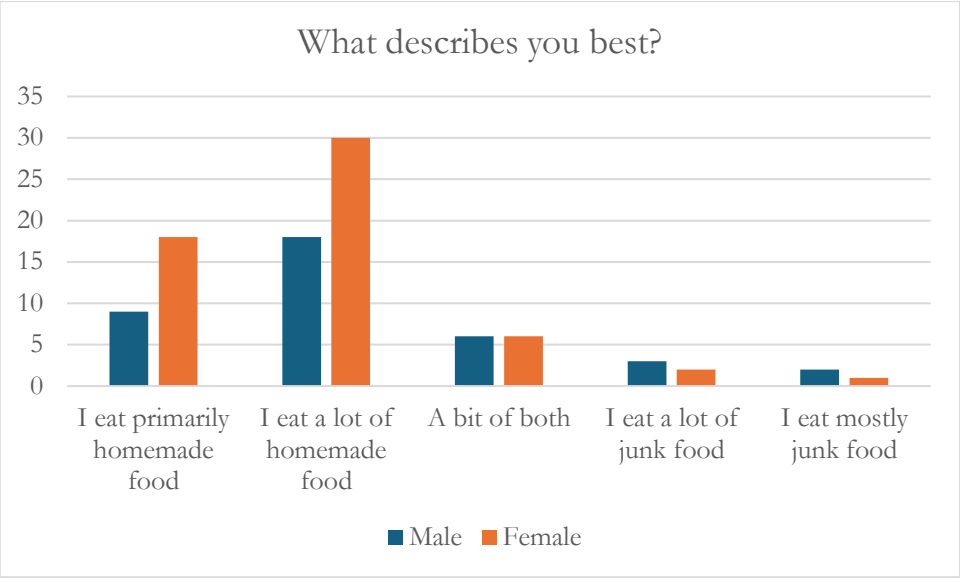

Figure 3. Homemade Food vs Junk Food

In Figure 4 below, you can see a graphical representation of how eating junk food affects university students globally.

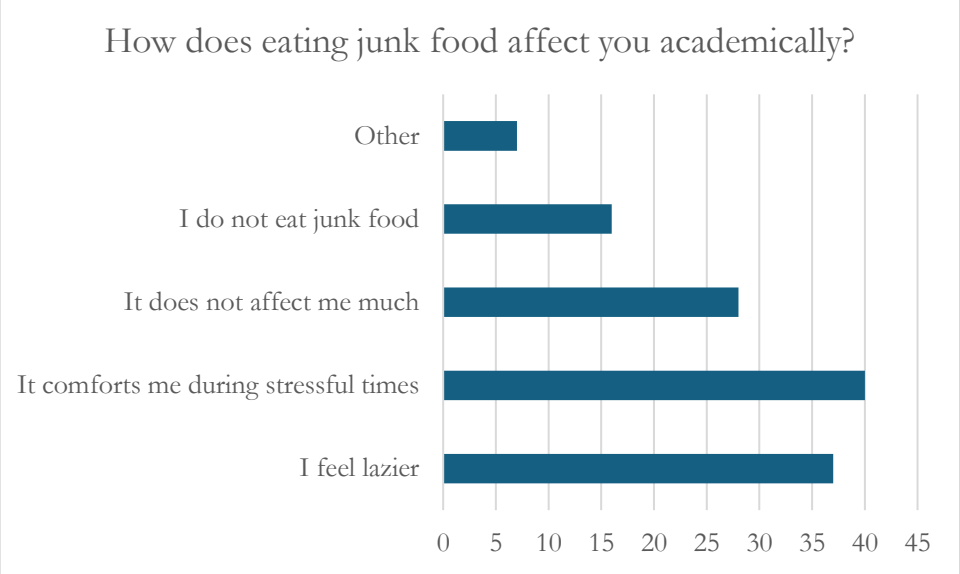

Figure 4. Academic Affect of Junk Food on Participants'

In Figure 5, you can see a graphical representation of factors that lead to poor eating choices among university students.

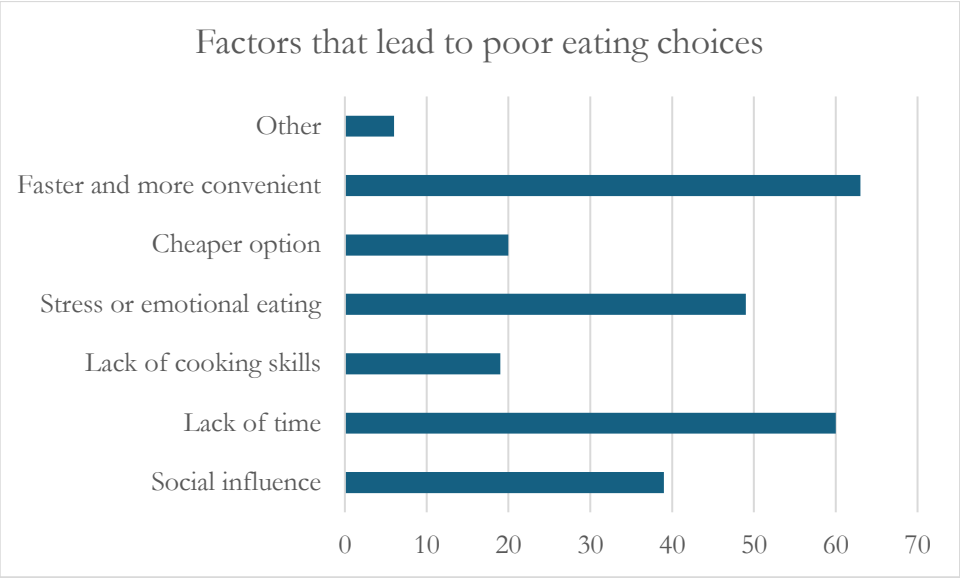

Figure 5. Factors Leading to Poor Eating Choices

In Figure 6, you can see a graphical representation of how different age ranges perceive their relationship with food.

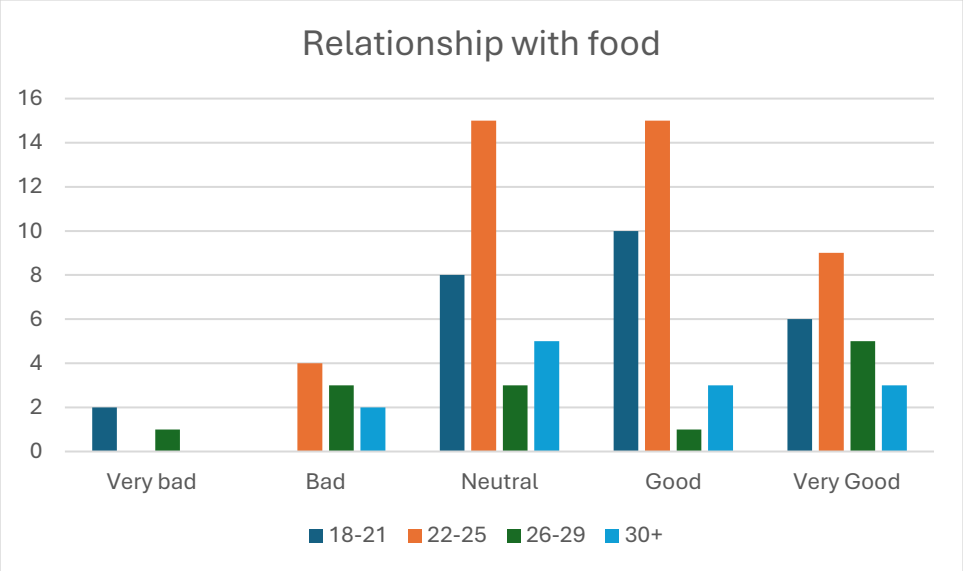

Figure 6. Participants' Relationship with Food

In Figure 7 below, you can see a graphical representation of the level of knowledge of both genders.

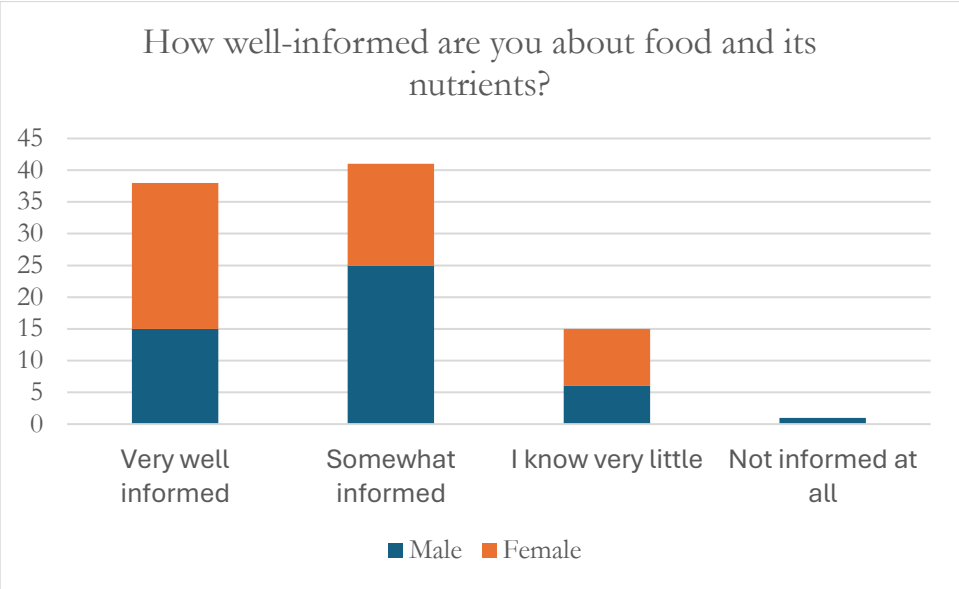

Figure 7. Participants' Nutrition Knowledge Level

In Figure 8, you can see a graphical representation of the usage frequency of nutrition apps among university students.

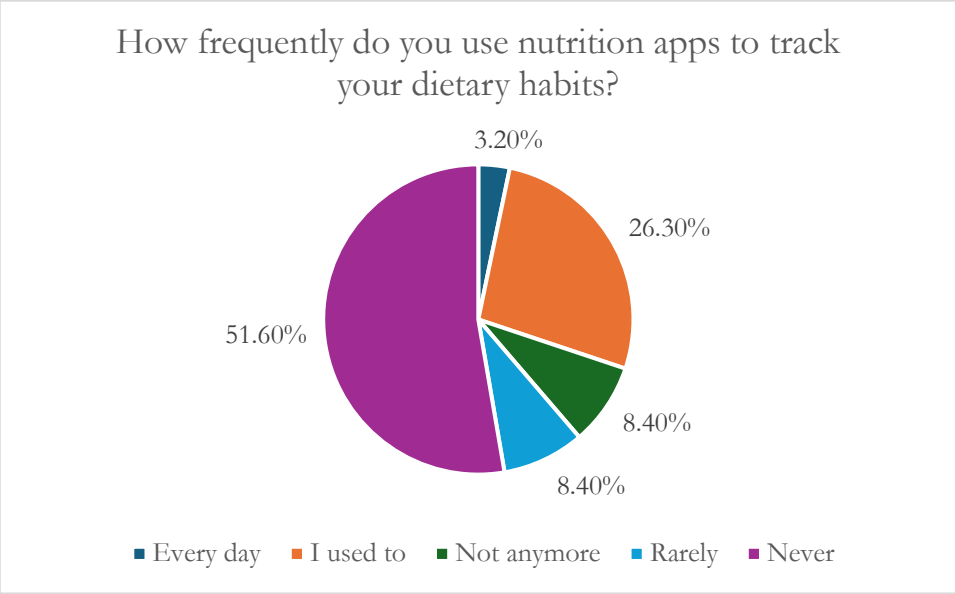

Figure 8. Participants' Nutrition App Usage Frequency

In Figure 9, you can see a graphical representation of why university students downloaded a nutrition app.

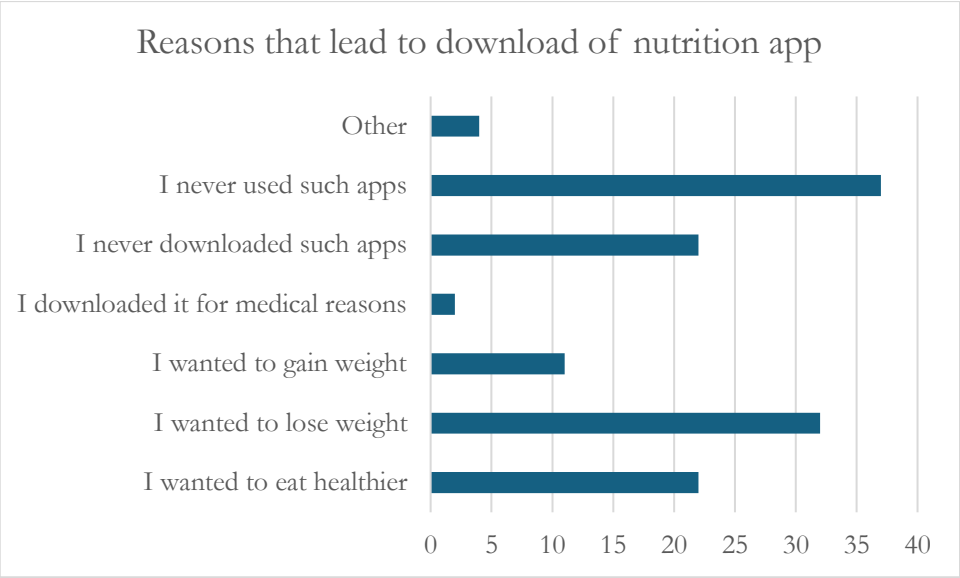

Figure 9. Participants' Reasons to Download Nutrition Apps

In Figure 10, you can see a graphical representation of female and male participants' satisfaction with nutrition apps in the market.

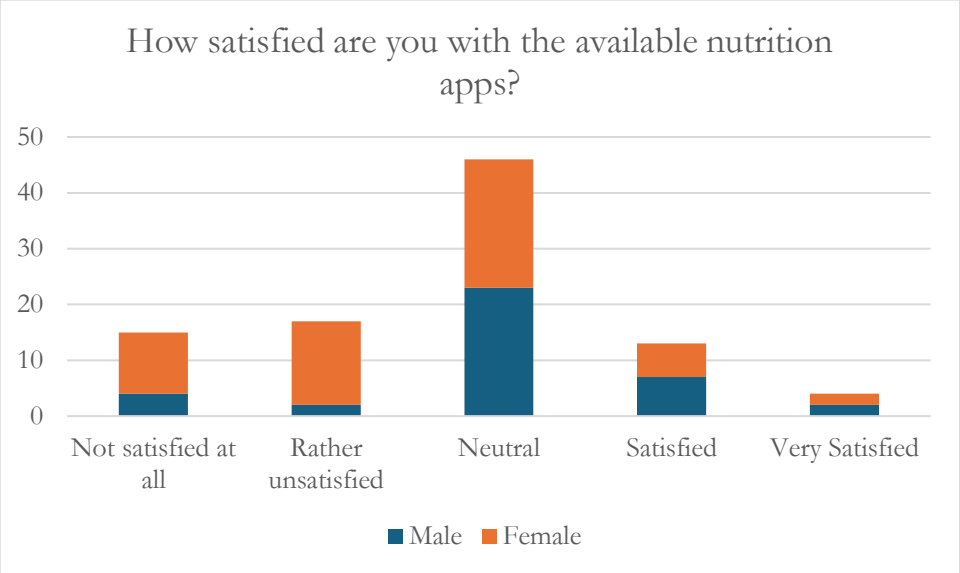

Figure 10. Participants' Satisfaction Level with Nutrition Apps

In Figure 11, you can see a graphical representation of the participants' opinions on whether nutrition apps adequately address user needs based on their age range.

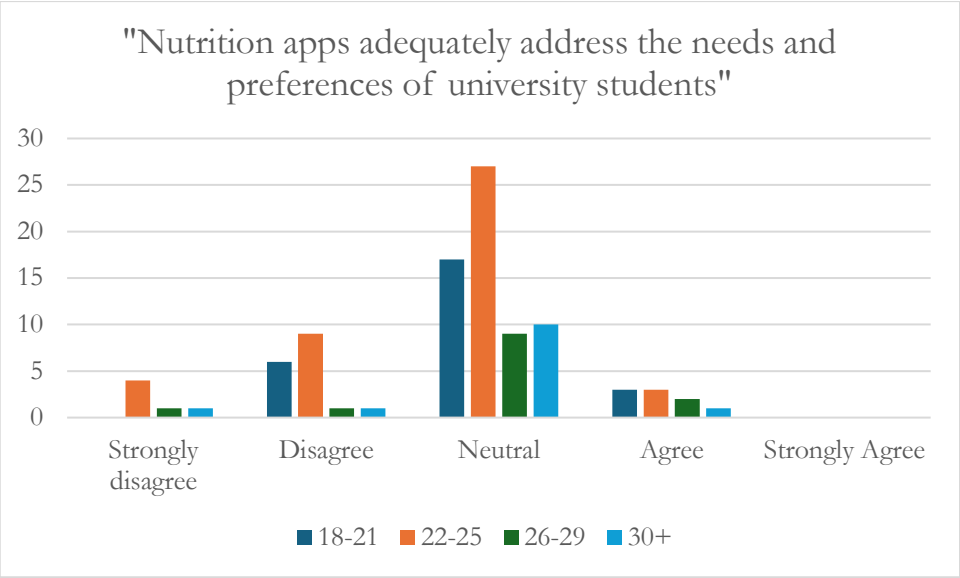

Figure 11. Participants' Opinions on Apps Addressing Their Needs

In Figure 12, you can see a graphical representation of features that university students would use in a nutrition app.

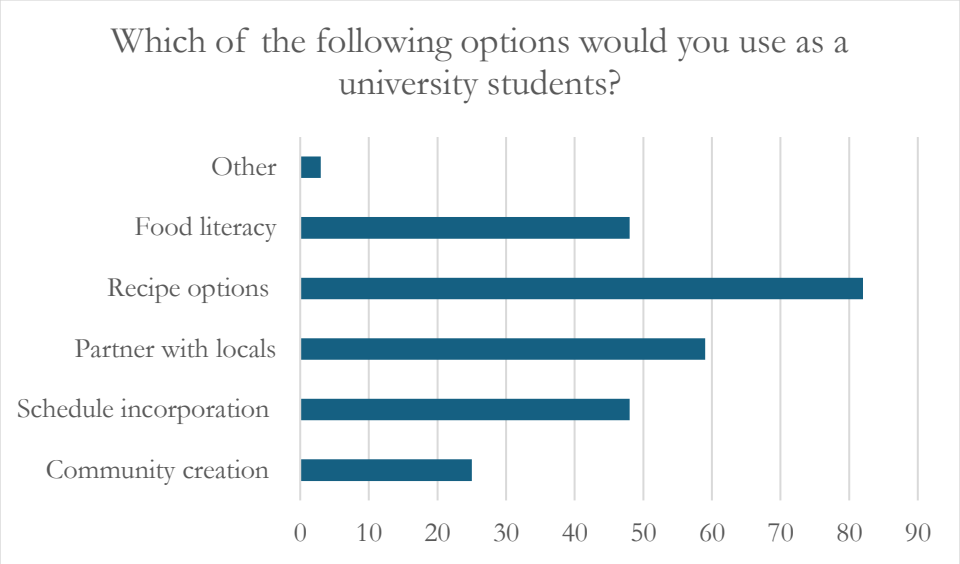

Figure 12. Nutrition App Features Preferences

The above-listed data is quantitative and will be interpreted in the next chapter. The following qualitative data in Table 4 describes the relevant responses to the open questions asked to university students.

Table 4. Findings From Open Questions From Survey[1]

Question	Quotes
Nutrition vs University	
1. Additional thoughts or experiences regarding the topic	S1: "Related to food, I don't find myself having challenges. If I happen to eat a less healthy food, it was a choice to maintain a good balance."
	S26: "Good food is essential for nourishing our bodies, providing the necessary nutrients for optimal health, and fostering overall well-being."
	S28: "While I'm at university, I find that, despite being minimally balanced, my diet is not varied. I restrict myself to certain ingredients to not waste food."
	S33: "I eat mostly non-junk food, but sometimes my mind says: today you can eat junk food (It just tastes really good sometimes)."
	S43: "Information and education is very important. In the case of a special diet, it is recommended to track it in a healthy way without pressure from outside."
	S52: "Emotional baggage from the experiences of the day or the traumas consume a lot of the energy, so I let myself down when it comes to healthy eating."
	S77: "I have always struggled with seeking comfort and positive stimuli through food, especially those rich in sugar. … I think college added to the stress levels."
	S87: "During university, most of the time, I eat healthy and enjoy it as I feel I am giving the right fuel to my body to think and feel better. … When I was more busy or stressed with exams, I may have neglected my meal quality and done something more quick."
Nutrition Apps	
2. Have you ever stopped using a nutrition app? If yes,	S1: "I have downloaded MyFitnessPal, but never really used it because I preferred to track my daily calories on a Google Sheet document with my own food."

[1] *Note*. S1= Student 1; S2 = Student 2; S… = Student …

Question	Quotes
what was the reason?	S6: "University was consuming more of my time."
	S7: "Yes, because it was a premium service."
	S10: "Some started costing too much money at some point, and it got annoying."
	S13: "Yes, because it takes too much effort to put in what you ate in a day and everything."
	S19: "Yes, too much commitment."
	S23: "It is time-consuming and demands time to have the correct information for each food per brand."
	S29: "Too much work to keep up with it."
	S31: "Nowadays, I'm more interested in giving my body the richest nutrients through different types of food instead of restricting myself to a thinner body."
	S44: "Yes, I didn't find it accurate or useful."
	S45: "I used to track my calorie intake to lose weight, but I find it exhausting to weigh every meal."
	S48: "Hyper-fixation on counting calories."
	S49: "I stopped using the app once I learned how to do food proportions according to their nutritional properties and macronutrients."
	S51: "It is hard to maintain regular use of such platforms considering I am travelling a lot for work and studies, so every place will have different cost factors or time limitations to cook and eat healthy."
	S52: "Yes, I didn't find it convenient enough."
	S55: "Yes, because it didn't feel like I was doing the right thing."
	S57: "Yes, too much work, not enough time to manage."
	S62: "I stopped because it was too much of a hassle to track everything I ate every day."

Question	Quotes
	S64: "It was annoying to keep track and also disheartening not to see progress after the given time."
	S65: "Yes, stressing about what to eat and how much."
	S69: "I started to get an unhealthy relationship with food. Food became numbers to me."
	S75: "Most of the time, I just forget about it."
	S77: "I never really trusted nutrition apps."
	S80: "Yes, I downloaded it to track my eating progress, but I didn't understand what I was consuming. … I informed myself online instead and now track it manually on an Excel sheet."
	S82: "Got lazy at a time I was busier with work and university."
	S83: "Free version was too limited."
	S91: "Hard to create a diet plan and follow it, so the app wasn't useful."
3. Can you name the nutrition apps and how they met your needs?	S1: "MyFitnessPal, and I think it is a good way to track the intake of calories per day. I would use the app if I didn't use a Google Sheet personalised to myself."
	S6: "Contador de calories. It would tell me how many calories I ate."
	S14: "Lose It! It helped keep track of calories."
	S37: "I used MyFitnessPal and one other app. At the time, I used them to count calories and keep track of what types of food I ate during the day."
	S46: "MyFitnessPal. It shows the calories of food."
	S52: "Leap fitness apps, they tracked the food, but I found they weren't well adapted to my eating habits."
	S57: "Noon - it seemed easy to use, but then it couldn't find the food via the pictures, …, too much friction."

Question	Quotes
	S58: "Mealtime was useful to inspire new recipe ideas. Eat this much to gain awareness of portion sizes."
	S62: "… For homemade meals, it's cumbersome to write the amounts."
	S64: "MyFitnessPal. It didn't meet my needs."
	S79: "MyFitnessPal. It just helps me track what I am eating and insert some foods that I really enjoy."
	S80: "MyFitnessPal and Yazio (to track calories)."
	S89: "MyFitnessPal, which helps count calories."
	S90: "My Fitness Pal. It helped me to control my daily calorie intake, but the app has a lot of wrong information, so I have to constantly search for the nutrition table of every food to insert a correct value."
	S94: "MyFitnessPal and Lifesum Food Tracker - I used them to track calories. I used FoodView for a while to take pictures of my food instead."
4. In your opinion, what features are crucial in nutrition apps to benefit university students?	S1: "I would like to have basic nutrition knowledge, but if you want to know more about it, there should be options to go further."
	S6: "Show me healthy restaurants that aren't that expensive."
	S7: "Market list, photo reader, chatbot with nutritionist."
	S37: "I think a nutrition app focusing on meal prep, intuitive eating, etc., could be beneficial to students."
	S39: "Indebt knowledge about food and nutrients."
	S49: "Affordable recipes, meal-prepping guidance, and dietary filters in a user-friendly interface with optional social features for tips and motivation."
	S51: "Time management tools and diet plans concerning the study burden and body conditions."
	S59: "Nutritional value, personalisation, advice on how to make cheaper, but nutritional options."

Question	Quotes
	S62: "I think the features should be based on the lifestyle that the students want to lead."
	S63: "Quick recipes with easy-to-prepare ingredients. Recipes that you can later reuse."
	S74: "I never used one, but maybe having healthy and fast meal options."
	S77: "Calorie calculator, meal ideas, healthy, affordable and fast recipes..."
	S86: "Easy to use and presenting the information clearly."
	S90: "The information provided needs to be correct. It should also have simple food recipes."
	S94: "Maybe a stress level scale. Many uni students undereat or overeat during stressful times, leading to symptoms as well. A gamified approach."
5. Final comments and insights.	S10: "I cook for myself quite a lot, but a practical app that helps me track everything better would help."
	S62: "Maybe implement some profiles with predefined features so that it might be easier for the users."
	S87: "I liked the idea of a nutrition app for university students."

Having obtained data from university students, we also wanted to get the perspective of the nutritionists.

4.3. Nutritionists Interview

To obtain the point of view of nutritionists, we created an interview questionnaire, dividing it into eight sections with a set of 17 questions. Before starting the interview, we briefly described the topic, indicating the title and objectives of this dissertation. In Table 5, we present the set of questions for each section.

Table 5. Interview Questions for Nutritionists

Section	Questions
General Information	1. Can you present yourself and describe your experience in the nutrition field?
	2. What motivated you to pursue a career in nutrition?
	3. Can you describe your usual type of client and the dilemmas related to nutrition that they usually have?
Nutrition Among University Students	4. Based on your experience, what nutritional challenges do university students commonly face?
	5. How do you evaluate the impact of eating habits on a university student's academic performance and well-being?
	6. In your opinion, what factors contribute to unhealthy eating habits among university students?
Technology in Nutrition	7. What is your perspective on the role of technology, particularly nutrition apps, in promoting healthy eating behaviours among university students?
	8. Did you find a specific challenge or limitation associated with using nutrition apps among your clients or university students?
Gaps in Existing Nutrition Apps	9. Based on your interactions with university students and clients, do you think existing nutrition apps adequately meet the needs and preferences of university students?
	10. Are there specific characteristics or features you consider missing or lacking in nutrition apps?
Opportunity for Innovation	11. In your opinion, which innovative approaches or functionalities could be incorporated into nutrition apps to better meet the needs of university students?

Section	Questions
	12. How do you predict technology will evolve to support healthier eating habits and nutritional education among university students in the future?
Professional Recommendations	13. What advice or recommendations would you offer app developers or designers to create or improve nutrition apps for university students?
	14. How can the collaboration between nutritionists and app developers improve the efficacity of nutrition apps in promoting a healthier lifestyle for university students?
Future Trends and Research Directions	15. In your opinion, what are some emerging trends or research areas in the field of nutrition and technology that have the potential to address the nutritional needs of university students?
	16. Are there any specific research questions or topics you believe need further investigation in this domain?
Final Considerations	17. Would you like to add anything else or share insights regarding the intersection of nutrition, technology and health among university students?

These questions aim to understand nutritionists' perceptions of the usage of nutrition apps to improve the nutritional habits of university students in the long term and debate the needs of university students regarding nutrition during academic periods.

4.4. Data From Interviews

We interviewed two nutritionists using the questions in Table 5 above and transcribed and translated them to retrieve their insights. In Table 6, we present quotes of the insights they gave through the interview that are relevant to this research.

Table 6. Findings From Interviews With Nutritionists[2]

Question	Quotes
General Information	
1. Can you describe your usual type of client and the dilemmas related to nutrition that they usually have?	N1: "Most clients seek to lose weight, some for medical reasons and very few for weight gain." N2: "I encounter young university students mostly … for weight loss objectives, but many combine it with nutritional re-education. Since my target audience is mostly young, I notice their tendency to fitness and their specific nutrition goals to support it."
Nutrition Among University Students	
2. Based on your experience, what nutritional challenges do university students commonly face?	N1: "They struggle to organise and plan their weekly meals because they lack time with their workload. They end up choosing Uber Eats and other easier solutions. Sometimes, they take meals from home but struggle to decide what to eat once it is done." N2: "... there are some cases where students … bring homemade food with them for the week, but it does not represent the majority, … they are entirely responsible for their meals, … so they end up choosing faster and more convenient options ..."
3. How do you evaluate the impact of eating habits on a university student's academic performance and well-being?	N1: "The impact is big since what they eat is not enough, and they end up being hungry after a while again since they ate food with no nutritional benefits, resulting in mental fatigue." N2: "It has a significant impact, considering that if the students go hungry for their classes, they will not have adequate performance and will not have the necessary energy to face the academic demand. … we are… talking about chronic fatigue because of the missing nutrients, which, of course, impacts their academic performance and health in the long term."
4. In your opinion, what factors contribute to unhealthy eating	N1: "Lack of time and facilitated access to Uber Eats. Some students … share a kitchen and do not have much room to store food in the fridge." N2: "Regarding individual factors, we have our own beliefs regarding nutrition; for example, students do

[2] *Note.* N1= Nutritionist 1; N2 = Nutritionist 2

Question	Quotes
habits among university students?	not eat vegetables at home, so they will not start eating soup at university either. It will also depend on the capacity to prepare their meals. Easy access to poorer nutritional options can lead to poor nutritional choices. … fast food is considered trendy among students, and then there are also group dinners that are considered societal norms and pressure students into choosing those less healthy options."
Technology in Nutrition	
5. What is your perspective on the role of technology, particularly nutrition apps, in promoting healthy eating behaviours among university students?	N1: "… the clients enjoy the interaction ... [but] it is constrained, and I do not agree with all the nutritional equivalents it presents. When I try to change it, it does not allow me to." N2: "… I notice the younger generation is clearly more interested … in technology related to nutrition, especially since I feel that nowadays they want to track a little bit of everything… it can be an important tool to promote positive habits if there is also a follow-up and prioritising of specific areas of nutritional behaviour that have to be changed individually."
6. Did you find a specific challenge or limitation associated with using nutrition apps among your clients or university students?	N2: "… traditional apps that track calories [are not] too adequate in some cases because it can lead to an excessive focus on calories… In terms of apps, it has a lot to do with the type of user because calorie tracking works for some users, while others prefer more variety in their meals and need guidance for changes in their meals."
Gaps in Existing Nutrition Apps	
7. Based on your interactions with university students and clients, do you think existing nutrition apps adequately meet the needs and preferences of university students?	N2: "There are no apps that focus on the food offered at the University … and its surroundings ... They do not just go to university, they are all around the campus, so having the option to check where they can find an accessible healthy meal, would be ideal."

Question	Quotes
8. Are there specific characteristics or features you consider missing or lacking in nutrition apps?	N1: "Maybe the updating of products because we are in an era where constantly new products are appearing, and the app needs to be up to date in that sense." N2: "It should be more focused on behavioural changes and some individual goals, not just them inserting their characteristics and the app providing their caloric intake."
Opportunity for Innovation	
9. In your opinion, which innovative approaches or functionalities could be incorporated into nutrition apps to better meet the needs of university students?	N1: "… keep the product list up to date, so they can establish the equivalents and be able to edit the dose of a product when building a plan." N2: "Maybe add a little more practicality to the apps by, for example, adding recipes based on the ingredients they have at home, and the app would then suggest what meals to prepare with them."
10. How do you predict technology will evolve to support healthier eating habits and nutritional education among university students in the future?	N1: "... my clients tend to want results fast, and establishing a nutritional re-education has not been easy. … they opt for supplements and artificial products without focusing on nutrition. Even with an excellent app, … it is tough to change their mentality on that." N2: "… artificial intelligence will be advantageous. Also, personalisation in the field of nutrition, with more biometrical data, will provide more personalised nutrition knowledge."
Professional Recommendations	
11. What advice or recommendations would you offer app developers or designers to create or improve nutrition apps for university students?	N1: "Maybe meal recipe ideas that are fast to make… [and] adding information on how long the products can be stored in the fridge or even outside the fridge..." N2: "I think an external intervention is often missing to help accomplish the individual objectives of the users. An option would be to add to the application the option to consult a professional online."

Question	Quotes
12. How can the collaboration between nutritionists and app developers improve the efficacity of nutrition apps in promoting a healthier lifestyle for university students?	N1: "It is the perfect combo because we know what gaps there are, and they know how to do it so that it would create the ideal app. " N2: "Having the point of view of nutritionists is important to understand what values should be added or what is missing in the apps that should be included to make them more appealing to the users."
Future Trends and Research Directions	
13. In your opinion, what are some emerging trends or research areas in the field of nutrition and technology that have the potential to address the nutritional needs of university students?	N2: "Nutritional personalisation for individuals with … medical constraints, where the app tracks … values and the app suggests, based on what the user consumed and how it altered their values, what should be consumed to normalise that value. … independently of the app providing what the user needs, it lacks the empathy to guide the user, so maybe the personalisation in that aspect."
14. Are there any specific research questions or topics you believe need further investigation in this domain?	N1: "...maybe the search for how much protein intake is necessary, especially with the fitness trend growing." N2: "… adding a fact check to know the nutritional information is correct, so some sort of stamp would be valuable..."
Final Considerations	
15. Would you like to add anything else or share insights regarding the intersection of nutrition, technology, and health among university students?	N1: "…I think it is necessary to pull them towards nutritional re-education and show them its importance." N2: "I think it is really important to have a communication bridge with the user, … it would be more interesting to have an intermediate that is more interactive for the client as well."

Both nutritionists show similar concerns regarding university students' nutritional behaviour and nutrition apps. The interviews provide valuable insights for developing this research, giving us the relevant perspective of nutritionists to support our conclusions.

4.5. Conclusions

The survey helped understand the concerns and habits of university students regarding nutrition apps. The interviews allowed us to listen to the perspectives of nutritionists regarding university students' needs and the efficacity of nutrition apps. The interpretation of the results obtained from the survey and interviews is presented in the next section.

5. Discussion

Now that we have presented the data obtained from the interviews with nutritionists and the survey from university students, we will discuss the results, analyse current popular nutrition applications, and provide innovations that could improve those apps.

5.1. Results Interpretation

To better interpret the results, we divided them into two topics to discuss the existence of a gap in nutrition applications and the university students' challenges and needs.

5.1.1. The Existence of a Gap in Nutrition Applications

This research has pinpointed several times the importance of identifying university students' needs regarding nutrition during academic periods. The university students who participated in the survey proved how little they adhere to nutrition apps, showing a gap in the existing applications. Over half of the students never use nutrition apps to track their dietary habits. Around 26% of them used to but stopped for diverse reasons, such as feeling overwhelmed by calorie counting and social pressure.

The complexity, required effort, and commitment to use such apps are among the reasons for uninstalling those apps. The expectation of having an app that meets their needs when seeing it in an ad, only to find out that it requires a premium subscription, is another reason students do not use nutrition apps. Their free versions are too limited and do not hook them enough to keep using them. Plus, users often find such apps sceptical and do not trust them or find them inaccurate.

Adding a more human touch to nutrition applications by integrating professionals would enhance the user experience, as Molina-Recio et al. (2020) highlighted, making them feel empathised in contrast to traditional nutrition apps. They also showed that the gap was due to the lack of collaboration between all the actors involved, which implies more future interaction and articulation.

Nutritionists find that apps can be an essential tool to promote healthy habits as long as they include individual follow-up for the users and prioritise nutritional behaviour and knowledge. Apps do not provide enough information, and users do not understand what they are consuming or do not know if they are doing the right thing most of the time. Since they have

to get informed about the nutrients elsewhere, they do not see the use in the app, so in some cases, they create a spreadsheet with their calculations of nutrients or give up.

The features students used in existing apps that met their needs were calorie counters, cooking guides, recipe ideas, portion size tools, and nutrition scanners. Most search for calorie trackers, although there is a general discontent towards the accuracy and variety of the foods in the database. The interviewed nutritionists also mentioned their concern about the restricted database and its incompatibleness with each country. The product list is limited, and the users must search and manually give the correct value, which is time-consuming and inconvenient.

Schedule incorporation, community creation, healthy and fast recipe options, local healthy restaurant options, food literacy, personalisation, nutritionist chatbox, behaviour drivers, diversity of ingredients, AI meal picture options, gamification, and affordability are some of the features that users would be eager to use in nutrition apps. Using AI in the future to increase the personalisation options in nutrition apps would be advantageous and possibly boost the retention rate of university students if they are adequately adapted to their needs.

The students equally value an app's simplicity, visual presentation, and practicality, which includes those features. Evans and Clarke (2019) confirm that an attractive design can boost nutrition apps' user experience and retention rate. The most popular apps university students use are MyFitnessPal, LoseIt!, Fat Secret and Yazio, although the retention rate in those apps is still slim. The reason behind that still needs to be further analysed.

5.1.2. Nutritional Challenges Among University Students

The testimony of university students shows that they face constant challenges when trying to lead a healthy diet through university. The temptation of fast food or tastier yet unhealthy food seems inevitable during university. It comforts students during stressful times, but they feel lazier when neglecting their nutritional habits too often, which impacts their academic performance. While some do not struggle or struggle less to maintain a healthy diet during academic stress, around 45% of the participants admitted to neglecting it often, if not wholly.

University students shared how they tend to neglect their meal quality when stress or emotional factors become overwhelming. Other factors that lead them to poor eating choices include social influence, lack of time, cooking skills, emotional eating, cost, and convenience,

which coincides with the findings of Abdelhafez et al. (2020) and Sogari et al. (2018). The access to poor nutritional options on faculty campuses plays a significant role, too, since exposure to those foods influences the eating patterns of university students. Some survey respondents expressed how they feel good when nourishing their bodies but sometimes want to include a cheat meal that they enjoy to balance their diets.

Students want a balanced diet without restricting themselves to certain foods or feeling guilty for occasionally eating less healthy. However, nutritionists find that students tend to eat too little and often with no nutritional benefits, which causes them mental fatigue and poor academic performance. They want fast results and frequently lack the patience or willpower to adopt a healthy lifestyle in the long term, leading them to be discouraged and neglect their food relation.

Their behaviour towards nutrition also varies depending on how informed they are about food and its nutrients. One of the nutritionists shared how their capacity to prepare meals and previous habits are also important factors for leading healthy eating habits. She stresses the importance of being informed, tracking the food consumed, and doing so healthily, without external pressure. However, when striving for a specific goal, like weight loss, students tend to restrict themselves or get obsessed with the calories without focusing on the nutrients.

The nutritionists noticed how the young generation of students shows interest in nutrition-related technology. They have tried using existing apps, commonly MyFitnessPal, to track their food intake and look for easy, cheap, personalised, instructive, and fast solutions in those apps. However, they tend to get lost in the variety of applications that mostly only partially address their different needs and stop using them at some point.

University students feel that current nutrition apps don't meet their needs and are cumbersome since they aren't adapted to their eating habits and often share wrong nutritional information. The reasons that led them to stop using apps include time consumption, cost, effort, commitment, inconvenience, and inaccuracy of food information. Since they had to look up accurate food information, some students just started to track their intake in Excel, not trusting the information provided in the apps and thus creating their own system.

5.2. Current Nutrition Applications

Based on university students' and nutritionists' preferences, we analysed and compared seven of their most mentioned nutrition applications. We picked out thirteen features and attributed whether they are premium or free for each app in Table 7 below.

Table 7. Existing Nutrition App Features [3]

App features	My Fitness Pal	Lose It!	Fat Secret	Yazio	Fastic	Life Sum	Food-visor
Calorie tracking	F	F	F	F	P	F	F
Macro tracking	F	P	F	P	P	P	P
Micro tracking	F	P	NA	P	P	P	P
Barcode scanner	P	P	F	F	P	F	F
Intermittent fasting	P	P	NA	F	F	P	NA
Recipes	NA	F	P	P	P	P	NA
Meal planning	NA	P	P	NA	P	P	P
Water tracking	NA	P	P	F	P	F	F
Exercise tracking	F	F	NA	F	F	F	F
Goal setting	F	F	NA	F	NA	F	F
Community	F	F	F	F	NA	NA	P
Personalisation	NA	NA	P	NA	P	P	P
Food education	NA	P	NA	NA	P	P	NA

Looking at the table, we can spot how applications focus primarily on calorie and exercise tracking, lacking various features informing students about the nutrients they consume.

[3] *Note.* F = Free; P = Paid; NA= Not Attributed

Without payment, neither app offers personalisation, food education, or meal planning. Only one app provides free recipes for the user; only two give at least the macro information of the foods, with only one showing the micronutrients. Barcode scanning is available for free in four of the apps. Intermittent fasting is only accessible in two applications, with water tracking in three. Goal setting is a fundamental feature in most apps, though often unrealistic. Finally, four apps have a free community within the app. All apps promote a premium version with paid extra features, including personalisation in four apps, food education in three, and meal planning in five.

5.3. Innovations to Fill the Gaps in Nutrition Applications

Based on the existing applications and features that meet students' needs most, according to their and the nutritionists' feedback and existing research, we created a list of innovative features meant to improve the university lifestyle in the nutrition domain in Table 8 below.

Table 8. Innovations for Nutrition Apps Tailored for Students

Features	Description / Contribution to University Students
1. AI with picture recognition	To take a picture of the meal and have the app detect the food and its nutrients without inserting it manually.
2. AI with voice recognition	It is being able to dictate the ingredients and quantities while cooking to gain time.
3. Nutrition quizzes	Have daily quizzes to stimulate users' knowledge of food in a gamification system.
4. Food literacy	Include articles, papers or other accurate information to educate on nutrition.
5. Scanning of products	Show the nutrition rating of the product and show healthier swaps.
6. Recipes with Variety	Give easy, tasty, fast, and healthy recipes with a list of ingredients already in the user's possession.
7. Caloric tracking	Calculate the required calories according to the user's goal.
8. Macro tracking	Calculate the necessary macronutrients according to the user's goal.
9. Micro tracking	Calculate the required micronutrients according to the user's goal.
10. Personalised meal plan	Provide a personalised plan with the ingredients the user enjoys without being restrictive.

Features	Description / Contribution to University Students
11. Community	Create a community that links users to other users with similar goals to motivate each other.
12. Food Behaviour	Help with stress management and habit creation, among other behavioural issues students face.
13. Personal (human) nutritionist	Have the option to have an online appointment with a professional or have them review the meal plan for advice or suggestions.
14. Food database	Ensure the database is current and reaches a wide range of countries.
15. Progress tracking	Allow for pictures and goal data to be stored and compared progressively.

According to the users' needs and existing innovations, incorporating most of the features listed in Table 7 will likely increase the overall usage of applications among university students. It is essential to highlight that even if the features are present and practical, the app's design plays a vital role in keeping users long-term. We cannot predict or control user behaviour when using the app.

Including app developers, nutrition professionals, users, and scientific research to optimise such apps tailored for university students could have a few setbacks, like the profitability of such apps since the cost is a barrier for students, but the app needs financing. Since popular apps offer freemium options, another intermediate solution could be offering a discount to university students or collaborating with faculties to promote healthy diets among students while maintaining it affordable and exciting for them.

5.4. Conclusions

Even with the vast range of nutrition apps in the market, university students still struggle to find one that meets and addresses their individual needs. According to existing research and nutritionists, adherence to nutrition apps implies willpower and commitment, which are behavioural. Design and user-centred apps are recommended to enhance adherence, as they intrigue the user more.

Existing applications traditionally focus mainly on calorie and exercise tracking and do not provide the guidance or knowledge about food users seek in those apps. Using AI and other innovations to meet the users' needs with a user-friendly design can increase the retention rate of nutrition applications and help university students reach a healthier, balanced lifestyle.

This research allowed us to identify the existence of a gap in nutrition applications, and through the adapted Design Science Framework (c.f. 3.1.), we were able to observe that innovation can solve the gap in nutrition applications. The literature review, survey findings and interview perspectives allowed us to determine the gaps that leave a new opportunity for innovation, identify the unmet needs of university students, identify the current innovation behind the nutrition apps and define a set of innovations to fill the gaps in nutrition applications. The above-listed recommendations for features for nutrition apps aim at the construction of an artefact characterised as an inventory of innovation opportunities for nutrition applications.

6. Conclusion

This research aimed to discover if innovation can solve the gap in nutrition applications for university students to develop a healthier food relation and behaviour. We have demonstrated the existence of a gap in current nutrition applications, notably the lack of personalised, user-friendly, and educational features tailored to the needs of university students, according to their feedback and the perspective of nutritionists.

Furthermore, the literature review showed that the gap is due to the lack of collaboration between technological companies, users, healthcare entities and academic parties. On the other hand, user behaviour is unpredictable, and drivers to stimulate that behaviour are recommended, though not guaranteed to be efficient, since users have different behaviours.

We have created a set of innovations to close the gap and improve the efficiency of nutrition app usage among university students. The findings indicate that integrating features such as AI-driven meal suggestions, real-time nutritional feedback, and interactive learning modules can significantly enhance the effectiveness of nutrition apps in promoting healthier eating behaviours among university students. These findings can contribute to the existing literature by providing a framework for developing more effective nutrition applications.

Despite the results and conclusions that were obtained, this study has some limitations. The sample size was limited to ninety-five university students from Portugal and Luxembourg, which may not represent the broader student population and intercultural needs. Additionally, the short duration of the study limits the assessment of the long-term impacts of the app features.

Future research should broaden the sample size and include diverse cultural settings to validate the findings. Extended studies are also recommended to test the effects of these innovative features on students' dietary habits. Further investigation into the integration of gamification could provide additional insights into enhancing user engagement and retention. Conducting interviews with nutrition professors and app developers could also be considered to obtain more input and feedback.

In conclusion, this dissertation highlights the importance of technology in promoting healthy eating habits among university students. Tailored nutrition apps can enhance dietary habits and overall well-being by addressing their specific needs. Finally, this study emphasises the importance of continuous innovation and research in developing nutrition app solutions to continue increasing the impact of these benefits on university students.

References

Abdelhafez, A. I., Akhter, F., Alsultan, A. A., Jalal, S. M., & Ali, A. (2020). Dietary practices and barriers to adherence to healthy eating among King Faisal University students. *International Journal of Environmental Research and Public Health*, *17*(23), 8945. https://doi.org/10.3390/ijerph17238945

American Dining Creations. (n.d.-a). How college students benefit from healthy meal plans. *American Dining Creations*. https://adc-us.com/blog/how-college-students-benefit-from-healthy-meal-plans/#:~:text=Consuming%20nutrient%2Drich%20meals%20and,improves%20energy%2C%20memory%20and%20focus

American Dining Creations. (n.d.-b). Why are students struggling to eat healthy in college? *American Dining Creations*. https://adc-us.com/blog/students-struggling-to-eat-healthy-in-college/#:~:text=Good%20food%20for%20students'%20brains,eat%2C%20so%20they%20skip%20meals

Amaral, I., Antunes, E., & Flores, A. M. (2023). How do Portuguese young adults engage and use m-apps in daily life? An online questionnaire survey. *Observatorio (OBS*)*, *17*(2). https://doi.org/10.15847/obsOBS17220232141

Åsberg, K., Eldh, A. C., Löf, M., & Bendtsen, M. (2024). "Simply complicated": Uncovering the processes of lifestyle behavior change among college and university students with access to a digital multiple lifestyle intervention. *Digital Health*, *10*. https://doi.org/10.1177/20552076241245905

Baerren, E. (2023, October 24). How important is nutrition to academic success? *Central Michigan University*. https://www.cmich.edu/news/details/how-important-is-nutrition-to-academic-success#:~:text=Increased%20access%20to%20nutritious%20food,test%20performance%2C%20graduation%20rates

Baungaard, C., Lane, K. E., & Richardson, L. (2023). Understanding nutrition students' knowledge, perceived barriers and their views on the future role of nutritionists

regarding sustainable diets. *Nutrition Bulletin*, *48*(4), 572–586. https://doi.org/10.1111/nbu.12649

Bell, E. (2022, December 15). Do diet apps work? This is what experts want you to know. *Reviewed*. https://reviewed.usatoday.com/health/features/do-diet-apps-work-what-know-before-signing-up

Brown, D. J., Charlesworth, J., Hagger, M. S., & Hamilton, K. (2021). A dual-process model applied to two health-promoting nutrition behaviours. *Behavioral Sciences*, *11*(12), 170. https://doi.org/10.3390/bs11120170

Chen, J., Gemming, L., Hanning, R., & Allman-Farinelli, M. (2018). Smartphone apps and the nutrition care process: Current perspectives and future considerations. *Patient Education and Counseling*, *101*(4), 750–757. https://doi.org/10.1016/j.pec.2017.11.011

Coman, M. A., & Checeches, R. M. (2024). Exploring students' perception of subjective food literacy: A model of educational practice. *Heliyon*, *10*(7), e28478. https://doi.org/10.1016/j.heliyon.2024.e28478

Dute, D. J., Bemelmans, W. J. E., & Breda, J. (2016). Using mobile apps to promote a healthy lifestyle among adolescents and students: A review of the theoretical basis and lessons learned. *JMIR mHealth and uHealth*, *4*(2), e39. http://dx.doi.org/10.2196/mhealth.3559

Estrada-Araoz, E. G., & Mamani-Roque, M. (2023). Assessment of the level of nutrition knowledge in nursing university students. *Salud, Ciencia Y Tecnología*, *3*, 622. https://doi.org/10.56294/saludcyt2023622

Evans, S. H., & Clarke, P. (2019). Resolving design issues in developing a nutrition app: A case study using formative research. *Evaluation and Program Planning*, *72*, 97–105. https://doi.org/10.1016/j.evalprogplan.2018.10.010

Franco, R. Z., Fallaize, R., Lovegrove, J. A., & Hwang, F. (2016). Popular nutrition-related mobile apps: A feature assessment. *JMIR mHealth and uHealth*, *4*(3), e85. http://dx.doi.org/10.2196/mhealth.5846

García-Mata, O., & Celis-Moscoso, I. (2023). Design and validation of a scale to measure food literacy among university students. *Revista Chilena de Nutrición*, *50*(4), 401-412. https://doi.org/10.4067/s0717-75182023000400401

Guiné, R. P. F., Florença, S. G., Aparício, G., Cardoso, A. P., & Ferreira, M. (2023a). Food literacy scale: Validation through exploratory and confirmatory factor analysis in a sample of Portuguese university students. *Nutrients*, *15*(1), 166. https://doi.org/10.3390/nu15010166

Guiné, R. P. F., Florença, S. G., Aparício, G., Cardoso, A. P., & Ferreira, M. (2023b). Food knowledge for better nutrition and health: A study among university students in Portugal. *Healthcare*, *11*(11), 1597. https://doi.org/10.3390/healthcare11111597

Hevner, A., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105. https://www.researchgate.net/publication/201168946_Design_Science_in_Information_Systems_Research

Ho, D. K. N., Chiu, W. C., Kao, J. W., Tseng, H. T., Yao, C. Y., Su, H. Y., Wei, P. H., Khanh, N. Q., Nguyen, H. T., & Chang, J. S. (2023). Mitigating errors in mobile-based dietary assessments: Effects of a data modification process on the validity of an image-assisted food and nutrition app. *Nutrition*, *116*, 112212. https://doi.org/10.1016/j.nut.2023.112212

Hoge, A., Labeye, M., Donneau, A. F., Nekoee, H. Z., Husson, E., & Guillaume, M. (2022). Health literacy and its associations with understanding and perception of front-of-package nutrition labels among higher education students. *International Journal of Environmental Research and Public Health*, *19*(14), 8751. https://doi.org/10.3390/ijerph19148751

Jabour, A. M., Rehman, W., Idrees, S., Thanganadar, H., Hira, K., & Alarifi, M. A. (2021). The adoption of mobile health applications among university students in health colleges. *Journal of Multidisciplinary Healthcare*, *14*, 1267–1273. https://doi.org/10.2147/JMDH.S310539

König, L. M., Sproesser, G., Schupp, H. T., & Renner, B. (2018). Describing the process of adopting nutrition and fitness apps: Behavior stage model approach. *JMIR mHealth and uHealth*, *6*(3), e55. http://dx.doi.org/10.2196/mhealth.8261

McNamara, J., Mena, N. Z., Neptune, L., & Parsons, K. (2021). College students' views on functional, interactive and critical nutrition literacy: A qualitative study. *International Journal of Environmental Research and Public Health*, *18*(3), 1124. https://doi.org/10.3390/ijerph18031124

Molina-Recio, G., Molina-Luque, R., & Romero-Saldaña, M. (2020). The importance of knowing and listening to all those involved in the design and use of nutrition mobile apps: Getting to know the Great GApp, *Nutrición Hospitalaria*, *38*(3), 555-562. https://dx.doi.org/10.20960/nh.03385

Montagni, I., Cariou, T., Feuillet, T., Langlois, E., & Tzourio, C. (2018). Exploring digital health use and opinions of university students: Field survey study. *JMIR mHealth and uHealth*, *6*(3), e65. http://dx.doi.org/10.2196/mhealth.9131

Mostafazadeh, P., Jafari, M. J., Mojebi, M. R., Nemati-Vakilabad, R., & Mirzaei, A. (2024). Assessing the relationship between nutrition literacy and eating behaviors among nursing students: A cross-sectional study. *BMC Public Health*, *24*(18). https://doi.org/10.1186/s12889-023-17468-9

Mummah, S., Robinson, T. N., Mathur, M., Farzinkhou, S., Sutton, S., & Gardner, C. D. (2017). Effect of a mobile app intervention on vegetable consumption in overweight adults: A randomized controlled trial. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(125). https://doi.org/10.1186/s12966-017-0563-2

Rana, Z. H., Frankenfeld, C. L., de Jonge, L., Kennedy, E. J., Bertoldo, J., Short, J. L., & Cheskin, L. J. (2021). Dietary intake and representativeness of a diverse college-attending population compared with an age-matched US population. *Nutrients*, *13*(11), 3810. https://doi.org/10.3390/nu13113810

Salas-Groves, E., Galyean, S., Alcorn, M., & Childress, A. (2023). Behavior change effectiveness using nutrition apps in people with chronic diseases: Scoping review. *JMIR mHealth and uHealth*, *11*, e41235. https://doi.org/10.2196/41235

Sogari, G., Velez-Argumedo, C., Gómez, M. I., & Mora, C. (2018). College students and eating habits: A study using an ecological model for health behavior. *Nutrients*, *10*(12), 1823. http://dx.doi.org/10.3390/nu10121823

Tamang, A. (2023, April 19). The impact of college stress on students' eating habits. *The Washburn Review*. https://washburnreview.org/44280/features/the-impact-of-college-stress-on-students-eating-habits/#:~:text=College%20life%20can%20be%20difficult,emotional%20eating%20as%20coping%20strategies

Tavakoli, H. R., Dini-Talatappeh, H., Rahmati-Najarkolaei, F., & Fesharaki, M. G. (2016). Efficacy of HBM-based dietary education intervention on knowledge, attitude, and behavior in medical students. *Iranian Red Crescent Medical Journal*, *18*(11) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5301994/