Fall 10-16-2021

What is the impact of usability in the context of a web platform for efficient management of a livestock farm?

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Qual o impacto da Usabilidade no contexto de uma plataforma web de gestão eficiente de uma agropecuária?

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ABSTRACT

This article aims to present a proposal for a scientific problem. The main objective is to evaluate the impact of usability on a web management platform for a livestock farm. This activity comprises individuals over 50 years old and with few studies and is characterised by low adoption of information systems. Thus, it is intended that with the creation of a web platform that aims to meet the needs of the sector, it is possible to measure the impact that the usability will have. This platform will be tested on several farms to validate its usefulness in a real environment. Besides presenting the objectives, this document will also address the research problem, related work and concepts, the research methodology to be implemented, and the expected results.

Keywords: Usability; User Experience; Web Application; Livestock farm; Farming

1. INTRODUCTION

In Portugal, Animal husbandry is an activity inserted in the primary sector of production. This activity has been present in our society since a long time ago, but it still has immense challenges that must be overcome. For Félix Ribeiro (2019), to do that, this sector should go through a phase called Agriculture 4.0 and comprises the technologies that will assist in solving the challenges that it will have to face.

Animal husbandry is an activity inserted in the primary sector of production. According to Guimarães and Pereira (2014), livestock farming is defined as the set of human activities that include the cultivation of land (agriculture) and animal husbandry (livestock). This food production is intended to produce food for humans and consists of food intended for non-human consumption and raw materials.

Characterisation of the population linked to this activity is described by INE (2020) as being largely composed of natural persons, about 95%, and the remaining 5% is composed of agricultural companies. Regarding natural producers, they are on average 62 years old and predominantly male. In terms of training, most of them have only practical agricultural training, and almost half, 46%, have only completed basic education.

Also, according to INE (2020), it is possible to verify that from the last census in 2009 until the 2019 census, these producers were ageing since the average age increased by two years. There was an educational increase level since the number of individuals with education above the 1st cycle rose from 26% to 43%. In figure 1, it is possible to observe two graphs, one for the year 2009 and another for the year 2019, both graphs are divided by gender, and it is possible to observe the level of schooling in terms of age.

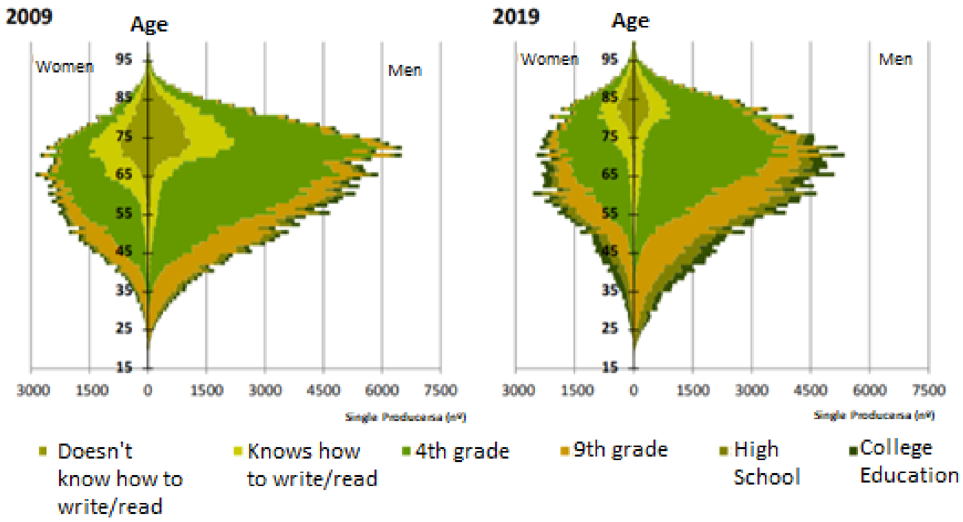

Figure 1 – Level of education for single producers in 2009 and 2019. Source: Agricultural Census (INE).

According to INE (2020), the average age of the managers of agricultural societies is 51 years old, the vast majority are male, and they have high academic and professional qualifications, with 48% of them having higher education qualifications. In figure 2, it is possible to observe two graphs, similar to figure 1, but in this case about the population that is part of the management of agricultural societies.

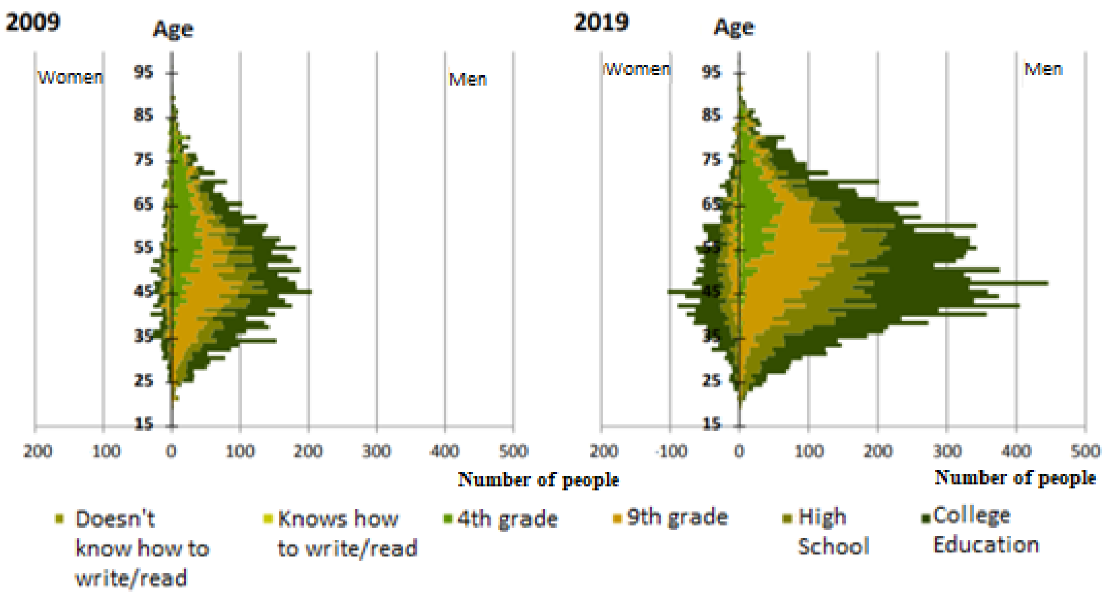

Figure 2 – Level of education for heads of agricultural societies in 2009 and 2019. Source: Agricultural Census (INE).

Agricultural activity has a significant impact in economic terms. In terms of employment, in 2020, 258,700 people, 5.4% of the employed population in Portugal, work in this sector. Despite this, as shown in Table 1, the number of people whose employment is in the area has decreased annually.

YEARS	TOTAL	AGRICULTURE, LIVESTOCK, HUNTING, FORESTRY AND FISHING
2008	5 116,6	585,3
2009	4 968,6	568,8
2010	4 898,4	548,5
2011	⊥ 4 740,1	⊥ 483,9
2012	4 546,9	491,4
2013	4 429,4	453,1
2014	4 499,5	389,1
2015	4 548,7	342,5
2016	4 605,2	318,4
2017	4 756,6	304,4
2018	4 866,7	294,2
2019	4 913,1	270,1
2020	4 814,1	258,7

Table 1 – Jobs, in thousands, total and in the agricultural sector. ⊥ - Break in series.
Source: Employed population: total and by sector of economic activity (PORDATA).

Moreover, still on the sector's economic impact, it is responsible for the production of goods that are equivalent to approximately 2.38% of the total Gross Value Added, according to the data provided by the PORDATA portal presented in Table 2. Through the table, it is possible to observe that despite the decrease in a number of related jobs, the gross value added of the sector has increased from 2013 to 2019.

YEARS	TOTAL	AGRICULTURE, FORESTRY AND FISHERIES
2008	156 158,2	3 517,2
2009	155 546,5	3 421,7
2010	157 970,8	3 479,2
2011	154 128,2	3 229,6
2012	147 214,8	3 238,2
2013	149 802,3	3 572,6
2014	151 135,8	3 592,8
2015	156 517,3	3 773,0
2016	161 993,3	3 852,5
2017	169 642,3	4 106,8
2018	177 465,9	4 178,6
2019	Pro 184 531,0	Pro 4 383,9

Table 2 – Value Added in the agricultural sector.
Source: Gross domestic product (GDP) from a production perspective (base=2016) (PORDATA)

This sector has immense challenges that must be overcome. These challenges are very diverse, ranging from the increase in population, which is estimated to reach 10 billion people in 2050, the reduction of available water in densely populated areas, the decrease in population in rural areas and finally, the decrease in available agricultural land (Félix Ribeiro, 2019).

Thus, an adaptation and development of it will be necessary to cope with the new challenges. For Harande (2009), this development will have to provide producers and agricultural societies with access to relevant information useful for their activities. This information is considered by Capurro and Hjørland (2003), as being raw material that will allow economic development for agricultural activity.

For Félix Ribeiro (2019), agriculture should go through a phase called Agriculture 4.0. This comprises the technologies that will assist in solving the challenges that it will have to face. This is part of an evolutionary process that began in the industrial revolution, and that has undergone changes and developments over the years, as can be seen in figure 3.

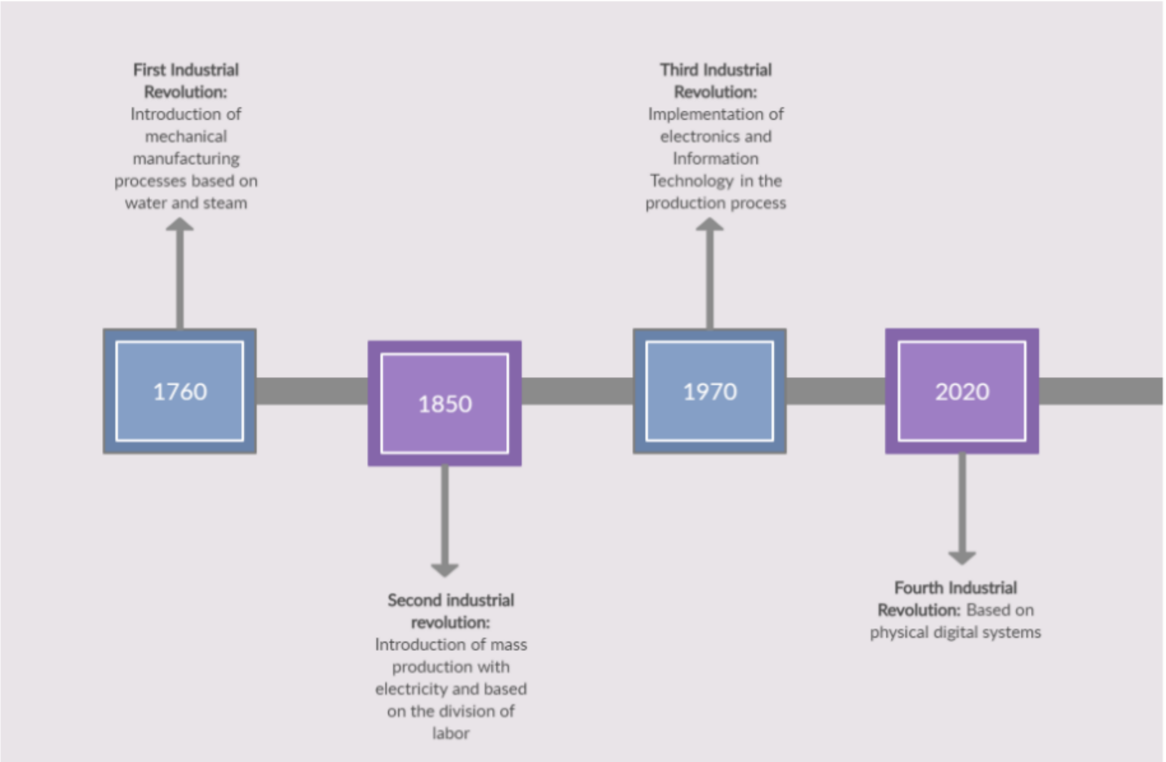

Figure 3 – Phases of technological change over the last two centuries.
Source: Agriculture 4.0 facing the food challenges in the medium/long term horizon (Félix Ribeiro).

According to Bascou (2019), due to the challenges facing the agricultural sector, both at the national and European level, most member states belonging to the European Union have signed a declaration that aims to cooperate to enable a smart digital future that is sustainable. Furthermore, this declaration recognises the potential that information technologies have in helping to solve the problems. Their use can lead to increased efficiency and improve the quality of life in rural areas. This improvement in the quality of life can attract more young people and thus help solve the problem of rural depopulation. As an example of technologies that can lead to the results mentioned above, we have the following:

- Artificial Intelligence
- Robotics
- Blockchain
- High-Performance Computing
- Internet of Things

- 5G Network

In addition to the above advantages, the introduction of these technologies can lead to:

- Reduction of costs
- Reducing environmental impact
- More efficient farm control

According to Pingali (2012), it is expected that the adoption of information technology will stimulate business transformation in this sector.

This paper is organised as follows: the second section presents the concepts and definitions important for the article's subject. The third section discusses the research problem. The following section, the fourth, provides the research methodology. Finally, the last section defines what the expected results are.

2. CONCEPTS

2.1. System Requirements

According to Preece, Sharp and Rogers (2015), a requirement is defined as a statement that refers to what a product should do and how it should do it. The gathering of requirements in constructing a system is of enormous importance because correctly identifying requirements can be the difference between a well-built system and a system with problems.

The identification of requirements Preece, Sharp and Rogers (2015) has two objectives. The first is to understand users and contexts in which they will use the system as much as possible. The second comprises creating a stable set of requirements that will be a basis for designing the system. Boehm and Basili (2001) also refer that this process should be well performed since the cost of identifying errors in a final phase of system creation instead of in a final phase may lead to a cost one hundred times higher. In the information technology area, requirements are generally divided into two areas, functional and non-functional requirements.

2.1.1.Functional Requirements

According to Brito (2010), the functional requirements describe the functionalities that the system should provide. In addition, these requirements are also responsible for defining which inputs, reactions or behaviours the system will have in certain situations. The functionalities referred to by these requirements should not be related to the technologies used since the system should offer them regardless of the technologies used in its construction.

2.1.2. Non-Functional Requirements

According to Brito (2010), the non-functional requirements describe the system's qualities rather than its behaviour. Moreover, these refer to how well a given system will perform its tasks, thus having significant importance in the system's quality. This impact on the system's quality leads to these requirements having a very strong weight on the attractiveness, security, usability and learning difficulty that the user feels in its use.

In this way, the user experience and software quality are assumed as non-functional requirements of great importance. Finally, the non-functional requirements are characterised by being interdependent since the satisfaction in one of them will not impact the satisfaction of the others.

The non-functional requirements affect usability. User Experience is not a definition belonging solely to the field of information technology. As Garrett (2010) supported, this term applies to any product that someone uses. According to Fernandez, Insfran and Abrahão (2011), the expression of usability should be taken into account not as something unique but as a set of characteristics such as performance, ease of learning, satisfaction and memorisation. Despite this, the characteristics and metrics of usability are not something widely defined in academia.

The official definition of the term usability is given by the ISO standard (2015) as being "the extent to which a system, product or service can be used by specified users to achieve specified objectives with effectiveness, efficiency and satisfaction in a specified context of use". Nielsen and Norman (2014) also refer that user experience defines "all aspects of the end-users interaction with the company, its services, and its products.

The IEEE (1992), further presents usability as "*the ease with which a user can learn to operate, prepare inputs for and interpret outputs of a system or component*." A widely used definition is given to us by Shackel (1986), who tells us that a product is usable to the extent that it allows flexibility, effectiveness, learning and user satisfaction. In addition, Lecerof and Paterno (1998) emphasise that the usability of a system is dependent on the user's needs for certain features such as learning, efficiency and security mechanisms. An example of these mechanisms in the case of information systems is a confirmation window to allow the user to back out of actions that have increased responsibility.

Moreover, this is a quality requirement of software products. Kirner and Saraiva (2007) state, "*Moreover, several studies have already shown that 80% of total maintenance costs are related to problems that users face about what the system does and not with technical bugs. Concerning these problems, 64% are directly related to usability issues...*".

2.1.3. Software Quality

The ISO/IEC 9126 standard is responsible for defining metrics to evaluate software quality. These metrics are composed of six characteristics:

- *Functionality*: Capacity to provide functions that respond to needs that can be both explicit and implicit
- *Reliability*: Capacity of certain software to provide a level of performance during its use, which is under the conditions that were previously established
- *Usability*: capacity that a given software has that the user understands, learns and uses it
- *Efficiency*: capacity of a given software to have a performance considered appropriate. This calculation is made considering the number of resources used

- *Maintainability*: capacity of a given software to be modified. This modification may originate both to make corrections and of making improvements and new functionalities
- *Portability*: capacity that a software product must be transferred from one environment to another

2.2. Usability Evaluation

According to Novák et al. (2019), there are several ways to test the usability of a web solution. Each has a different degree of acceptance by users and a different benefit level for the application developers shown in table 4.

METHOD	LEVEL OF ACCEPTANCE	BENEFITS FOR FARMERS
Questionnaires	90%	6/10
Remote usability testing	70%	8/10
Complex interviews	55%	7/10
Usability tests in the laboratory	35%	9/10

Table 3 – Different methods for usability testing respective information (Novák et al., 2019).

Thus, questionnaires are the methods that have the greatest acceptance by users. The reasons for this are that they are not the very time or resource consuming. The main benefit of applying them is that they allow a quick survey of the most comprehensive requirements of an information system to be developed, enabling prototypes for the system.

The remote usability tests, in turn, have the advantage that, as the name indicates, they do not require the physical presence of the user. One reason that leads to a lower acceptance rate than questionnaires is that they must be done per call simultaneously, requiring a more robust internet connection and more time availability. This method brings greater benefits to the developers than the previous one. Users can give real-time feedback on the feelings and frustrations they are experiencing towards the system. These tests work as follows: the user is given a set of scenarios that they must follow to accomplish a task.

Complex interviews are characterised by, similarly to remote usability testing, being more time consuming when compared to questionnaires which justifies their lower adherence. In addition, since the questions are more complex and in-depth, users feel less comfortable exposing their motivations. From the point of view of the solution developers, this method provides much valuable information since it allows them to assess the motivations and problems that users encounter in their routine and to understand where the system can fit in.

On the other hand, Lab usability tests are simultaneously the most beneficial for the system developers and the least adhered to by the users. From the users' point of view, this method requires a physical presence on-site and greater investment in terms of time spent. From the point of view of the system's creators, this type of test brings immense benefits because it allows for the analysis and collection of data that are impossible with other methods. This data consists of users' visual tracking, heartbeat, and non-verbal reactions.

3. Research Problem

The present proposal has its main objective of evaluating the impact of usability in a web management application. Moreover, this also aims at the following points:

- Design and specification of a web platform for efficiency management in agriculture and cattle ranching.
- Impact of Human-Computer Interaction, with an application of Usability techniques, in the platform's design, development, and testing.
- To understand reasons that lead to the low adoption of technologies in the sector.

After analysing the data mentioned in the previous points, it is possible to conclude that there is an effort to introduce information technologies in the sector. It is also possible to verify that they are already on offer in the market. In addition, it is already proven that their implementation in the sector will bring numerous advantages and added value.

According to GPP (2019), adopting information technologies in Portugal is easier in agricultural societies than in individual producers. As supported by INE (2020), it is verified that these producers are in a more advanced age group, above 60 years old. This fact should be considered since users in this age group have specific characteristics that influence how they interact with technologies. Thus, according to Chadwick-Dias et al. (2002), the technologies should be adapted to their specific characteristics.

In addition, also according to GPP (2019) these are characterised by a low level of education. This creates a challenge for digital agriculture that, in addition to the above factors, the geographical areas where the farms are located condition the installation of technical means, dependent on an internet connection, and according to data from 2017, the coverage value was 78.5%, as can be seen in the following chart:

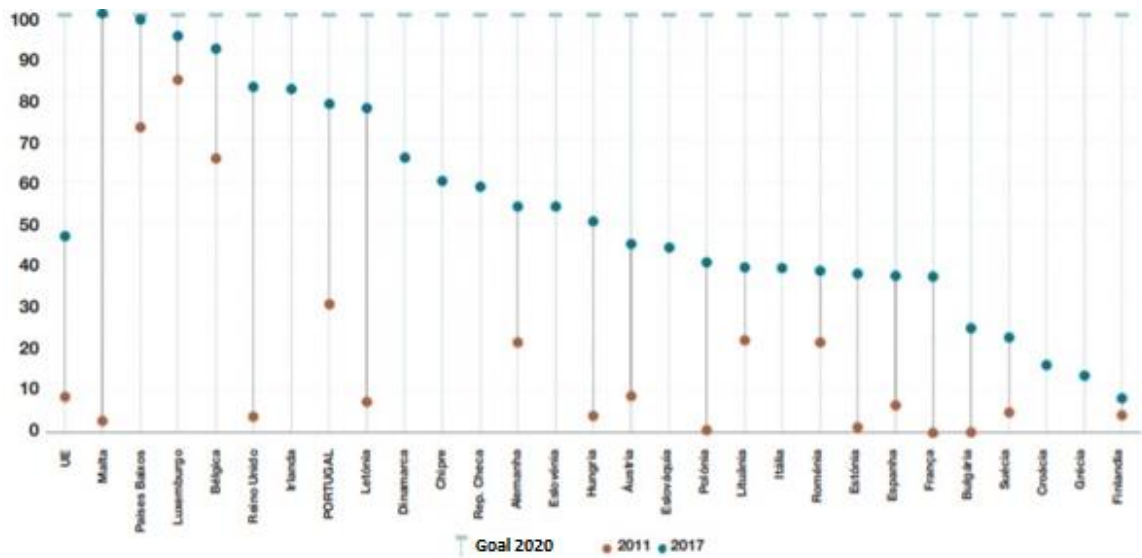

Figure 4 – Broadband coverage in the European Union for the years 2013 and 2017.
Source: based on data from the European Commission, "Digital Scoreboard

Thus, it is important to create solutions that help overcome the barriers caused by socio-demographic and geographic factors.

Fortes (2004) says that besides the factors mentioned above, there is some fear of using software in this type of industry, specifically in animal husbandry. These fears are due to the lack of confidence in the quality of the software presented for this area.

Thus, the platform should be created according to the users' needs to assess usability's impact on this type of technology and its potential users. Moreover, it is expected that by developing users' functional and usability needs, they gain confidence in adopting information technologies.

4. RESEARCH METHODOLOGY

The research methodology adopted is the Design Science Research (DSR). This methodology was chosen because, according to Peffers et al. (2007), it allows for developing new technologies to solve problems with socio-technological characteristics. The implementation process of this methodology consists of 6 steps.

First is characterised by identifying the problem and the motivation, second by defining the objectives for the proposed solution, third by design and development, fourth by demonstration, fifth by evaluation, and finally, the sixth by communication. It is expected that at the end of this process, a technological artefact will have been created.

In the second step of the design science research, the definition of the objectives, a questionnaire of the users' needs will be done. For its preparation, a protocol will be defined based on the concepts in the book Methodology of Research in Social Sciences and Humanities by Clara Coutinho. The concepts used will range from choosing an appropriate sample, collecting data, and analysing it. After this step, the collected data will be treated through the IBM SPSS software. With this step, we hope to have the correct survey of needs to define the system's functional requirements to be implemented.

In the third step, design and development, the software will be developed based on user-centred development. As Costa and Costa (2013) state, "*this methodology is characterised by having the direct participation of users in it and the creation of prototypes to be evaluated by them during the implementation*".

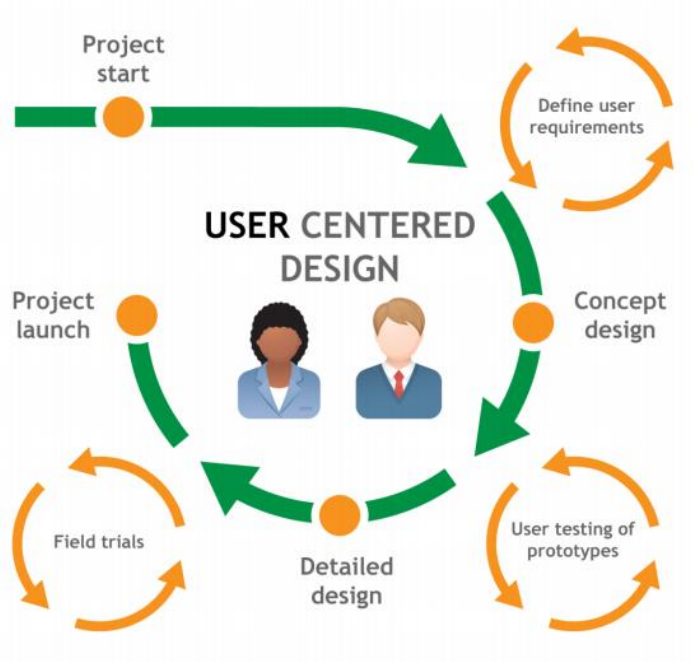

Figure 5 – Representative scheme of User Centered Design.
Source: Design for Users (https://www.baianat.com/books/ui-as-an-asset-for-ux/design-for-users)

Also, in this step, to validate the application's usability, a Heuristic evaluation will be performed, following the method provided in How to Conduct a Heuristic Evaluation by Jakob Nielsen. According to Nielsen and Molich (1990), this evaluation methodology allows usability problems to be discovered in the application to be resolved in advance. This evaluation should be carried out with a certain set of designated evaluators who will evaluate the interface considering a set of heuristics defined. The reason for this evaluation's choice is that, according to Jeffries et al. (1991), the evaluation by heuristics finds three times more problems than the evaluation by users.

The application will be subject to field use by the defined group for the fourth and fifth steps. The group is composed of five males and one female. Their ages are between 50 and 65 years old. Both six individuals work in livestock farms and fall into the category of sole producers. During a previously defined period, they will use the application in their daily lives. At the end of the period, evaluation surveys will be done to measure the impact of usability.

5. Expected results

The main expected result of the implementation of this proposal is to develop a web application that allows the efficient management of livestock farming, namely for the sole producers. Thus, it is expected that the developed platform assists in solving management problems identified in the environment. This way, it has the potential to be used frequently and habitually in a professional environment. Furthermore, it is expected that with the user-centred development, it will be possible to obtain a degree of usability that satisfies users and allows them to use the application easily and intuitively.

For the academy, it is expected that the execution of this proposal will demonstrate the impact that a web application that pays attention to usability and other sector-specific factors can bring to a sector characterised by low adoption of technologies.

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