An investigation of actors' differences in the perception of learning ecosystems' smartness: the case of University of Aveiro.

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Abstract. In this paper we report on a first investigation aimed at identifying possible differences in the perception of the campus' smartness among the players - bachelor students, master students and professors - that animate learning processes and campus' life at University of Aveiro. The detected differences, as discussed in the body of the paper, can be ascribed to the different roles of the individuals, to the increasing experience of the campus' life and, of course, to expectations. These latter can be used as basis to activate a design process to achieve a higher level of campus' smartness.

Keywords: Smart Learning Ecosystems, Smartness Detection, Universities' smartness, Smart Campus, PCA, Design for Smartness

1 Introduction to the "smartness" of learning ecosystems

As well known each year a considerable amount of money is spent in the production of University rankings that, however, are based almost exclusively on process and product indicators - weakly related to the quality of the learning process - and do not consider the perceptions of the players that animate such processes, e.g. bachelor students, master students and professors, etc..

These and other critical issues that affect top-down approaches to the elaboration of University rankings have been analyzed in few recent papers [1,2] and a need to explore alternative and complementary bottom-up approaches emerged [3,4]. As part of ASLERD's activities (Association for Smart Learning Ecosystems and Regional Development [12]) a group of members of the Association developed and validated an alternative approach to the benchmarking of learning ecosystems [5]. Such novel approach has been inspired by the Maslow's Pyramid [6] and by the definition of the Flow state [7]. Accordingly, provided that basic individual's needs are satisfied, all individual actors of the learning process - students, professors, administrative staff,

etc. - are candidate to achieve the state of flow [8], i.e. a state where challenges are exciting and adequate to the skills owned by the individuals, which, in turn, are expected to be improved due to the challenges.

While referring the reader for a detailed description to previous publications [3,4], here we resume briefly the procedure that has been developed. First internal and external elements composing a learning eco-system - infrastructures, services, social life, challenges, skills, etc. - and data typologies (subjective and objective, qualitative and quantitative) have been mapped onto the Maslow's Pyramid of needs, slightly redefining its inner layers. Afterwards, using such mapping as guidelines, a questionnaire aimed at collecting the opinions of all actors operating within a learning eco-system has been elaborated to collect both numerical indicators and textual opinions on all levels of the Maslow's pyramid of needs and, as well as, on parameters strictly related to the achievement of the state of flow. The questionnaire is available on-line as appendix of ref. [5]

According to the definition of ecosystems' smartness [2-4]:

"smart ecosystems/contexts are ecosystems/contexts where individuals that animate the local processes (and thus the human capital) own not only a high level of skills, but are also strongly motivated by continuous and adequate challenges, provided that their primary needs are reasonably satisfied"

it can be fully determined only when data from all actors of the educational processes - students, teachers, technicians, administrative staff, etc. - are collected to produce the indicators described in the next paragraph. Usually, however, it is quite difficult to involve all such categories in a trials of reasonable dimensions and because of this in the past ASLERD's members have focused their efforts on extracting the learning ecosystems' smartness as perceived by students [5]. A decision more than reasonable as first approach considering that all learning ecosystems are expected to be centered on students and their needs.

With the present work, focused on the University of Aveiro, we started to investigate the differences that may exist in the perception of the Campus' smartness among the different categories of players that animate the learning processes and the Campus' life.

In the following sections we first describe how data were collected and validated, then the analysis that was performed on the data; finally we provide some hints on how the results of our analysis can be used to boost a design process aimed at improving the smartness of the Campus.

2 Data collection and validation

As in previous investigations the questionnaire described in ref. [5] was pre-validated by the local campus research coordinator. Observations were collected and the questionnaire adapted according to the coordinators' requests. Once a full agreement was achieved, the final version of the questionnaire was made available for anonymous filling through an instance of the on-line learning environment LIFE [9].

The survey was announced by email to all the university's functional and organic units (departments and schools). The link to the on-line questionnaire, then, was delivered to each player (teacher, student, researcher, non-teaching staff) after having institutional clearance from the departmental Dean and the functional unit Director.

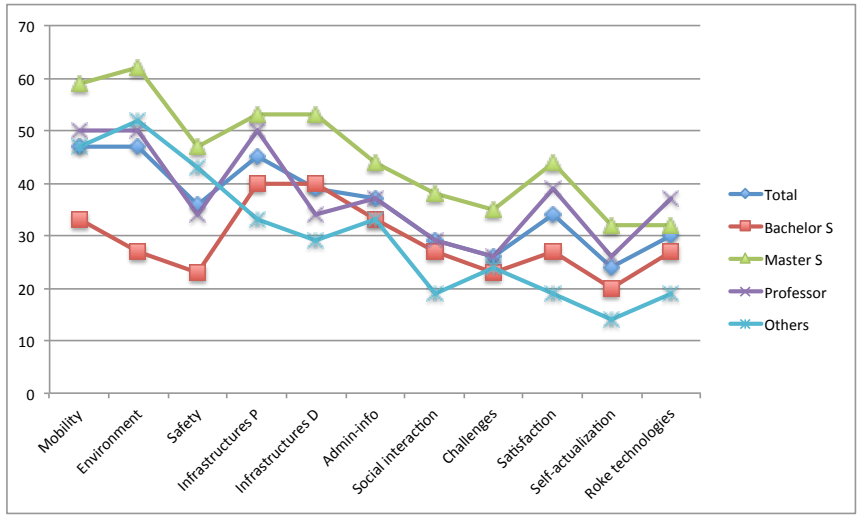

Fig. 1. Percentage of people that answered to the open qualitative questions as function of the sequence of presentation of the questions

The questionnaire was answered by 122 people: 30 bachelor students, 33 master students, 38 professors and lecturers, with the rest of the participants belonging to other categories.

To investigate the level of involvement of the participants we have plotted the number of answers that have been collected as function of the sequence of the questions for both closed/quantitative questions (only the input of a numerical value on a scale 1-10 was required) and open/qualitative questions, see fig. 1 and 2

As far as closed/quantitative questions we observed a decrease of only 8% in the number of answers between the first and the last question. A decrease that has to be ascribed mainly to professors and bachelor students.

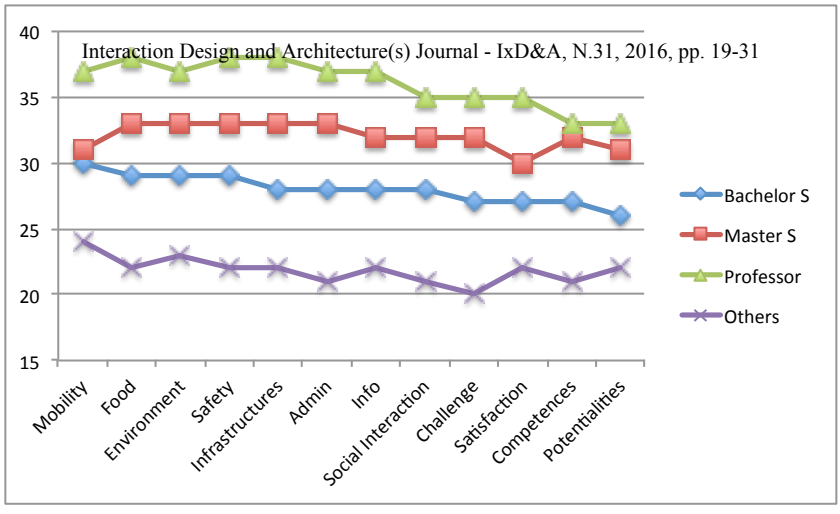

Fig. 2. Percentage of people that answered to the close quantitative questions as function of the sequence of presentation of the questions

On the other hand if we consider the open questions and make abstraction from the first and third questions that asked to explain choices (about mobility and lunch consumption), rather than descriptions of problems or wishes, we observed that the number of people that answered the second question ranged between 59% (master students) and 33% (bachelor students), overall 47% in average. For open questions the average decrease in the number of answers, between the second and the last open question, was around 17% (ranging from 6% for bachelor students and 27% for master students).

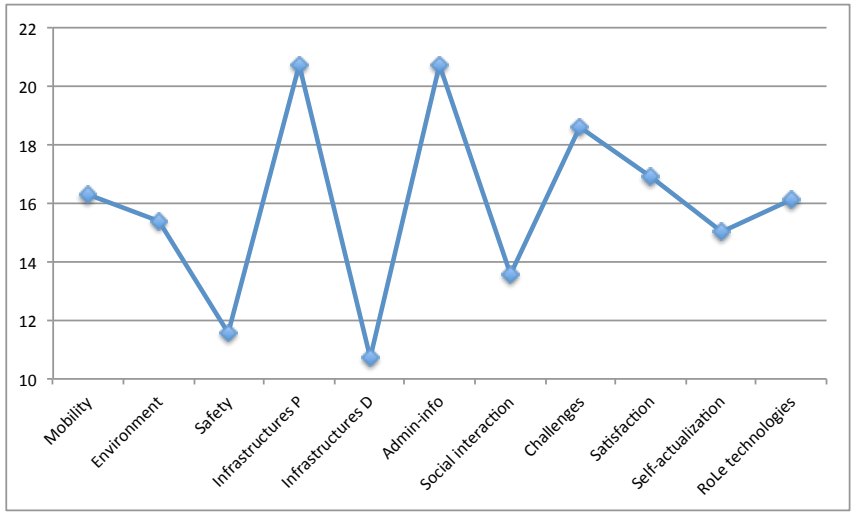

Fig. 3. Average number of words used in answering the open qualitative questions as function of the sequence of presentation of the questions

To be sure that such "tiring effect" did not affect also the quality of the answers we measured the average length of the answers, in words, see fig. 3. It oscillates from question to question but no decrease in the average length of the answers has been detected. This means that people that got tired just gave up answering open questions. However around half of them continued to answer the quantitative questions.

An inspection of the open answers' texts confirmed their significance.

3 Segmented analysis of "smartness" perception and expectations

Table 1 and fig. 4 show the mean values of the 10 numerical indicators extracted from the answers given to the quantitative questions. As usual for this kind of investigations, although the indicators are related to different aspects of the learning ecosystems, they may show relevant correlations that, of course, have to be investigated using data collected from many different learning ecosystems to identify an adequate space of representation within which the ecosystems can be compared on the basis of the perceived level of smartness [2,5].

The primary goal of this paper, however, is to determine the differences among the perception of the various categories of players animating the learning processes, as far as the smartness of the learning ecosystem is concerned. Because of this we investigated what we may call "internal correlations", i.e. the correlation among the opinions expressed by different categories of actors operating within the same Campus, see indicators of Table 1. We first inspected the correlation matrix and removed the indicators characterized a high number of strong correlations ($R > 0.7$). Then, by means of a Principal Component Analysis (PCA) [10,11], we were able to determine the orthogonalized reduced space that, by minimizing the number of dimensions (i.e. indicators) allows to get the higher loading on the first two principal components, Y1 and Y2. As result we identified a four dimensional space - *Infrastructure, Environment, Safety and Challenge* - characterized by a loading of 84% on Y1 and Y2. Fig. 5 shows that the positions of the various categories of players are well separated apart on this reduced two-dimensional space. Such separation is the landmark of a different perception about the smartness of the campus.

Due to the positive and large contribution of all the indicators to Y1 the position along this axis can be considered the perceived level of *university's smartness*. It appears to be relevantly higher for bachelor students than for master students and professors. The position on the Y2 axis of the bachelor students is largely determined by the high perceived level of *safety*, while that of the professors appears to be determined at the same time by the perceived level of *safety* and by lower values attributed to *infrastructures* and *challenge* indicators.

Table 1. Mean values of the indicators extracted by the answers to the quantitative questions: the scale ranges between 1 and 10 (the questionnaire is reported in appendix of ref. [5]).

Indicator/University	All	B students	M students	Professors/ Lecturers	Other workers
Infrastructure	7,24	7,36	7,18	6,97	7,38
Food services	7,48	8,28	6,88	7,26	7,62
Environment	7,26	8,31	6,91	6,57	7,08
Info/admin services	6,63	7,27	6,25	6,24	6,97
Mobility	8,34	8,93	8,19	7,97	7,92
Safety	8,53	9,31	7,97	8,79	7,62
Support to social interactions	7,26	8,11	7,25	6,54	7,08
Satisfaction	7,26	7,59	7,07	7,00	7,38
Challenge	7,00	7,67	7,31	6,14	6,45
Self-fulfillment	7,23	7,76	7,16	6,79	7,08

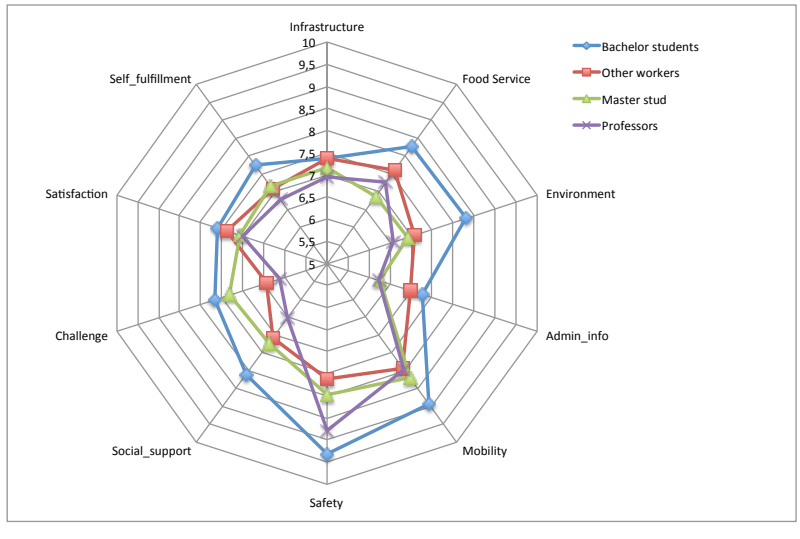

Fig. 4. Radar representation of mean values of the indicators reported in Table 1

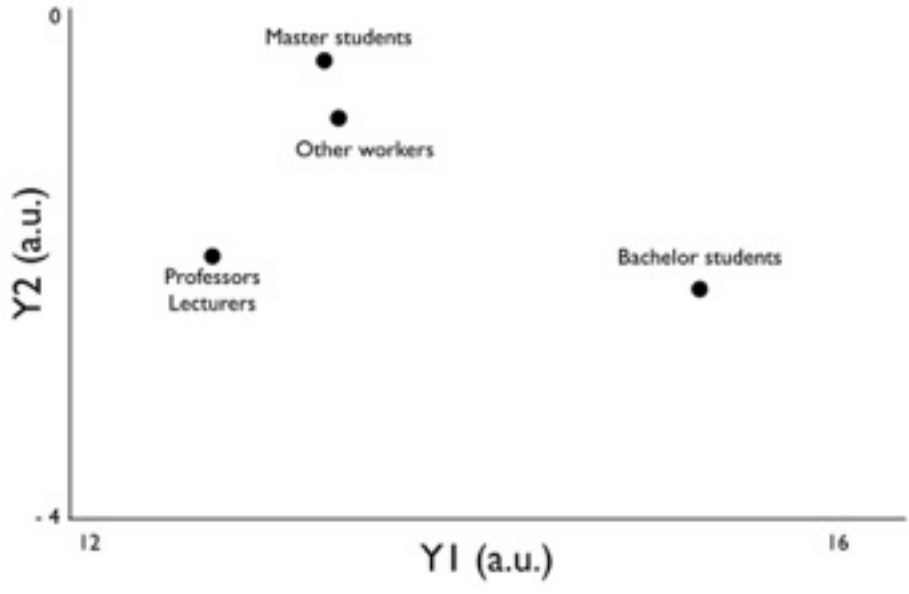

Fig. 5. Positioning of the different categories of players on the plane identified by the two principal components, Y1 and Y2, derived from a PCA applied to the reduced set of the four indicators: *Infrastructure, Environment, Safety and Challenge*

To have a better insight on the difference of the perceived level of smartness we have analyzed the texts of the open answers looking first at the occurrences of the words that have been used and then, when needed, by direct inspection of the answers. Table 2 shows the outcomes of such analysis that seems to confirm the conclusions derived by the analysis performed on the quantitative answers. As far the *safety*, in fact, bachelor students did not detect any problem and professors pointed out few problems that appear less relevant with respect to those described in more details by master students (that, for example, may have suffered bicycle robbery during their longer stay in the campus). As another example, if we look at the indicator *challenge* we observe that bachelor students wish to have more exchange opportunities and contacts with companies, while master students are more concerned with the lack of a sufficient number of internships/scholarships and hope for stronger support to internationalization. Professors are complaining with the present level of international exchange too, but also with the lack of adequate information and support to the exploitation of potential opportunities. They also invoke a more adequate appreciation and valorization of the efforts done in exploiting opportunities and in promoting advanced didactic activities. To assign the right weight to the above

concerns, however, we have to stress again that on average only about 30% of the participants answered to the open questions. They are thus representative of about one third of the sample, although in reasonable agreement with the outcomes of the quantitative analysis.

Many other interesting issues emerged from the analysis of the texts but their detailed discussion goes beyond the aim of the present work and will be left for future comparative analysis that will involve several European Campuses. Some of them, however, will be dealt with in the next paragraph to show how the outcomes of the bottom-up approach used in this study may also serve as a starting point towards the design of a process aimed at increasing the university's smartness.

Table 2. Keywords and topics emerging from the analysis of the texts of the open qualitative answers. In brackets the occurrences, after the colon specifications of the keywords.

Indicator/University	B students	M students	Professors/Lecturers
Infrastructure	poor WI-FI connectivity (2); lack of socialization and studying rooms; *wishes:* luggage storage service; microwave oven; minimarket;	poor WI-FI connectivity (11); unsatisfactory studying places (5); noisy classrooms; old computers (3) & equipments; building maintenance (2); heating (4) *wishes:* better library (5); bike (4: slot to park, university service); grocery	buildings (4: maintenance, noise), not well equipped classrooms and labs (6); bathroom maintenance; no socialization spaces: poor wifi (2) wishes: parking places (car and bike); walking pathways; pharmacy and minimarket
Food services	queue (2: canteen)	canteen (6: crowd (2), waiting time, noise) bar (expensive & not healthy)	canteen (2, slow, distance, queue), bar (not good quality), restaurant (3: expensive, healthy (2), hot meal)
Environment	poor separate waste collection; green area maintenance	waste/garbage (9): poor separate waste collection (6), insufficient N. of bins/containers (9); too many cars, lack of park seats, few parking slots for bykes	bins (4: insufficient number); paper (4: no separate collection); recycling (more organization, more information) waste/litter (5: poor separate waste collection, no action plan); energy (2: more attention to consumption); smoke (2): lack to reserved place to); green area (3: not just grass, maintenance);

Indicator/University	B students	M students	Professors/Lecturers
Info/admin services	no clear information on admin procedures and website (4); poor organization, long waiting time and customer care (3)	no clear information on admin procedures and website (6); unsatisfactory services (6: slow, lack of ticketing service, customer care, lack of mobile application)	no clear or not updated information (3); lack of process tracking; poor support by technical services; lack of cloud services
Mobility	internal distance because of rain; signage/orientation; pavement maintenance	buildings (8: internal distances & timetable, signage, raining weather, speed of bikers) campus/ university (3)/ department (2)/ classrooms(5): missing signage & maps	buildings (7: distance, rain (6), wind(4)), bike: secure and protected parking slots & infrastructures), respect of pedestrians by car drivers, signage (2) architectural barriers (ramps/stairs)
Safety	nothing detected	night/dark (7) lack of guards (2) robbery (2: bikes); no security agents; camera in some areas; drug sellers	lack of security information/awareness (2); lighting at night (3), need security agents at night; fire alarm disabled
Support to social interactions	access sport facility	poor support to internationalization and networking (4: enterprises); poor student integration(2), scarce cultural activities	poor support to socialization and no action plan; lack of opportunities and dedicated spaces
Satisfaction	*wishes:* more practical activities; better networking with productive realities (2); ability to listen	*wishes:* more practical activities (3); more useful didactic content also skill oriented (2); more internships (2); more Erasmus opportunities	*wishes:* less admin tasks (3); more transdisciplinary interaction (4); more international R&D and educational initiatives; better networking (companies) recognition of efforts (2); reduced teaching load;
Challenge	poor support to exchanges (2) and tweaking with companies	scarce N. of internships/ scholarships (3); poor support to internationalization; low productiveness	poor support to trans-disciplinary internationalization; poor support to exploit opportunities; lack of recognition

Indicator/University	B students	M students	Professors/Lecturers
Self-fulfillment	*wishes:* involvement in working experience & innovative teaching	*wishes:* more workshops (3) & practical challenges (3); more cultural initiatives	*wishes:* stronger support to participation in projects and conferences (2); clearer internal communication; more international exchanges and collaboration; more opportunities for training and personal development; support to innovative teaching; more adequate working loads
Housing	cleaning (2), noise (2); heating; safety	expensive or small flat/ room (10); poor appliances (3): poor internet connectivity (2); noise (2); relationship with owners (2)	

4 Toward a Design for "smartness"

According to the definition of smartness that has inspired the bottom-up approach used in this study (see par. 1) the smartness of an ecosystems should be interpreted as the ultimate goal of an on-going process rather than a static attribute of an ecosystem. Being the goal of such transformative and resilient process it has necessarily to be supported by a design process.

The questionnaire used in this work, as shown in the previous paragraphs has been designed not only to provide numerical landmarks for benchmarking (see Table 1) but also to support the problem setting phase included in the *investigation* layer and of the "organic" process of design, an experience based one [13,14]. Table 2, in fact, offers to the designers a reach set of indications on how to put in place a process to step towards the campus' smartness.

The most evident request is for on-line technologies, possibly available also on smart phone, that from one side may facilitate the access to local services to optimize processes, and from the other offer mentoring and act as facilitator. Actually a mobile application is already available for free, fig. 6: UA Mobile [15], but accordingly to the outcomes of the questionnaire there is room for improvements to optimize one of the most important individual resources: time. Indeed it should help to reduce the time spent in the queues (to take the lunch or to access administrative services) and, because of this, should offer a reservation and ticketing facility to be complemented by a process tracking (i.e. to track the status of the queue or the progress of the administrative procedures). With reference to meals, the application could also offer

the possibility to choose the meal to enhance customer satisfaction and optimize the consumption of food resources (also to reduce waste production and to help in programming the provisions) and, as well as, "home" delivery (at university buildings) for those that have no time to move to the canteen. This latter service should be accompanied by the identification of spaces suitable to favor social interaction and sharing, spaces that may also help to solve the problem of "not soundproof" canteens and that may be equipped with appliances such as microwave oven, fridge, coffee machine, etc.. In particular, some of such spaces could be positioned to favor contacts among people working in different domains (to foster inter-disciplinar exchanges with a reduced loss of time). Integration and exchanges could be favored also by the design of socialization corners - maybe having different and integrated functionalities - that could be placed in the park surrounding the university buildings.

Fig. 6. Screenshot of the homepage of the UA Mobile app.

Also connected with time saving is the request for an optimized time-table and usage of the lectures' halls, to reduce walking distances and transfer time from one lecture to the next, also to mitigate the trouble that may be provoked by possible rain falls. The minimization of the commuting time could certainly be also supported by a more efficient outdoor and indoor signage system that should be offered not only in electronic form (more relevant for last minute changes) but also as physical evidence of the location of buildings, halls, bureaux, etc.

Still related to time saving is the possibility to improve the mobile app with geographical positioning information on available parking slots for car or bicycle that

introduce the interplay between mobile application and the physical computing: i.e. sensible parking area. Expectations by bikers, however, are more structured: e.g. the increase of secure parking slots (to limit bike thefts) and the separation between walking and biking paths (to allow for quicker transfer and protect pedestrians). Still on bikes: another possible action could be the offer of an internal (to university) service to borrow bikes when people wish to minimize the transfer time. Similarly a RFID/NFC based service could be offered to borrow umbrella to mitigate the problems caused by sudden and unexpected rain falls.

As far as the facilitator role of the technology, the UA mobile application is expected to promote and support social interaction (and related action planning) and student integration, internationalization and territorial networking (i.e. to facilitate internships, job placement and career development).

The application could also be improved to include service evaluation, support to social recognition for the efforts done in favor of the university, but also to improve clarity and correctness of information about all services and administrative procedures offered by the university. Moreover it could possibly offer access to open data and, why not, to offer a mediation on occasion of house renting (to prevent student discrimination, help to keep the cost of the flats at a reasonable level and support trusted relationships between students and owners).

On the physical computing side the "well being" of all actors and the smartness of the campus could be further increased by implementing luggage self-storage services, a system of intelligent light systems in the park. To preserve the environment, finally, the participants advocate the implementation of an efficient system for separate garbage collection that, in principle, could be supported by automatic detection of the filling levels of the bins and by gamification strategies to foster social responsibility. Also related to the environment preservation is the request to distribute detectors of light consumption that could provide also open access data and produce public evidence within the campus through dedicated signage.

The request for a wider wi-fi band and for the availability of better technological equipments for the classrooms/labs are, to some respect, trivial because related to the improvement of basic infrastructural resources that do not demand for relevant and creative design interventions.

5 Future Developments

Being this the first work that reports on differences in the perception of the campus' smartness by the actors animating the educational process, the next step will be to compare the outcomes of this work with results obtained by similar investigation performed on other campuses. A second direction of investigation is represented by a comparative study on the perception of the city's smartness to foster the emergence of possible correlation among the smartness of the Aveiro University and that of its

territory of reference. A third possible path of research is the application of the same method to detect the perceived level of smartness in other local learning ecosystems like the schools (K12 and High schools). Finally an additional direction is represented by the development of the design process to produce detailed concepts and the improvement of the applications sketched in the previous paragraph to support the realization of a Smarter Campus in the Aveiro University.

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