



MATHEMATICAL METHODS AND APPLIED COMPUTING

**Proceedings of the APPLIED COMPUTING CONFERENCE 2009
(ACC '09)**

**Proceedings of the 11th International Conference on
MATHEMATICAL METHODS AND COMPUTATIONAL
TECHNIQUES IN ELECTRICAL ENGINEERING
(MMACTEE '09)**

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Mathematics and Computers in Science and Engineering
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Plenary Lecture 10

Campus Web based Information System for Monitoring Quality of Life: A Case Study Applied to the University of Minho



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Abstract: Universities have been recognised as an active agent in the society development and evolution. One of the marks of this acknowledgement was the Magna Charta Universitatum. This document sustains that their role is to promote cultural, scientific and technical development of new generations, as well as the whole society, providing permanent training. It also says that such education should teach and train future generations to respect the great harmonies of their natural environment and of life itself. Joining that relevance to campi extension and to the university community dimension, the quality of life in campi became a critical feature for the management and sustainable development of that type of urban areas.

In addition, there is a consensus about the fact that Portuguese Universities are leaving a period of continuous building growth, incoming in a cycle of stabilization and consolidation. The demand tends to be satisfied. So, a new process shall emerge where the physical expansion will be substituted by a quality and sustainable process where the equity will become more relevant. Also, the quality of teaching and research activities in Universities are somehow related to the quality of the spaces where they take place, either when considering the buildings' facilities, or when taking into account the campus area. Some authors have concluded that the students' perception of their overall academic experience and the campus environment is related to academic accomplishment. Furthermore, keeping and increasing the quality of life in public spaces is also recognised as a critical aspect concerning the urban sustainable development perspective.

When analysing characteristics, form, dimension and organisation of university campi, it can be concluded that they can be seen as urban spaces. This fact is often enhanced by their location: in urban areas or even merged in the city. In this context, a model for the evaluation of the quality of life based on concepts for urban spaces is presented. Its main purpose is to provide conceptual bases for the implementation of a decision support system that evaluates the campus quality of life and its sustainable development. The process integrates the users' perception and provides the ability to assess the impact of future interventions on the campus quality of life using scenarios. Those scenarios can be created by a tool included in the system and enabled to measure, through indicators, changes in campus. The evaluation of the quality of life variation that would result from the scenario execution will serve as a decision support tool for campus management when studying several possibilities.

The case study explores and shows the web based information system for monitoring the quality of life of the Gualtar Campus of the University of Minho, located in Braga, Portugal. Basically, the model aims at determining a global index of the Quality of Life in the Campus (QIC) variation, comparing different moments in time. The system embodies two main functions related to its sustainable development process: (i) to inform the community, allowing any user to know which are the considered indicators and their actual values, and how the QIC has evolved; (ii) to serve as a decision support tool, mainly in facilities planning and management, thus allowing to compare the impact of several scenarios on several quality of life dimensions, through an evaluation that integrates the users' perception.

Brief Biography of the Speaker:

Rui Ramos is an assistant professor of Civil Engineering Department, Engineering School, University of Minho, Portugal. His area of expertise is Urban and Regional Planning and he is a PhD Researcher at Territory, Environment and Construction Centre from University of Minho. In 1993, at University of Minho, he started his regular work as a lecturer and researcher. Since then he published as author or co-author over 40 scientific papers in reviewed journals or presented at international conferences. Moreover, since 2000, he had the opportunity to be an invited Professor at the Department of Transportation of the School of Engineering of Sao Carlos, University of Sao Paulo, Brazil.

Campus Web based Information System for Monitoring Quality of Life: A Case Study Applied to the University of Minho

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In addition, there is a consensus about the fact that Portuguese Universities are leaving a period of continuous building growth, incoming in a cycle of stabilization and consolidation. The demand tends to be satisfied. So, a new process shall emerge where the physical expansion will be substituted by a quality and sustainable process where the equity will become more relevant. Also, the quality of teaching and research activities in Universities are somehow related to the quality of the spaces where they take place, either when considering the buildings' facilities, or when taking into account the *campus* area. Some authors have concluded that the students' perception of their overall academic experience and the *campus* environment is related to academic accomplishment. Furthermore, keeping and increasing the quality of life in public spaces is also recognised as a critical aspect concerning the urban sustainable development perspective.

When analysing characteristics, form, dimension and organisation of university *campi*, it can be concluded that they can be seen as urban spaces. This fact is often enhanced by their location: in urban areas or even merged in the city. In this context, a model for the evaluation of the quality of life based on concepts for urban spaces is presented. Its main purpose is to provide conceptual bases for the implementation of a decision support system that evaluates the *campus* quality of life and its sustainable development. The process integrates the users' perception and provides the ability to assess the impact of future interventions on the *campus* quality of life using scenarios. Those scenarios can be created by a tool included in the system and enabled to measure, through indicators, changes in *campus*. The evaluation of the quality of life variation that would result from the scenario execution will serve as a decision support tool for *campus* management when studying several possibilities.

The case study explores and shows the web based information system for monitoring the quality of life of the Gualtar *Campus* of the University of Minho, located in Braga, Portugal. Basically, the model aims at determining a global index of the Quality of Life in the *Campus* (QIC) variation, comparing different moments in time. The system embodies two main functions related to its sustainable development process: (i) to inform the community, allowing any user to know which are the considered indicators and their actual values, and how the QIC has evolved; (ii) to serve as a decision support tool, mainly in facilities planning and management, thus allowing to compare the impact of several scenarios on several quality of life dimensions, through an evaluation that integrates the users' perception.

Key-Words: - Quality of Life, Decision Support System, University Campus, Public Participation

1 Introduction

Over the past few years, studies about the quality of life have increasingly been focusing on urban reality, as the majority of the world's population lives in urban places. This is certainly a reason for the appearance of a new line of research on the quality of urban life [11]. The European Commission has also recognised that Health and the Quality of Life are top priority areas of the Sixth Environment Action Programme [4]. It even says that, for people living in cities, a good quality of life largely depends on the quality of the urban environment.

On the other hand, Universities have been recognised as an active agent in the society development and evolution. One of the marks of this acknowledgement

was the *Magna Charta Universitatum* [13] where it is sustained that their role is to promote cultural, scientific and technical development of new generations, as well as the whole society, providing permanent training. The Commission of the European Communities [2] refers that the growth of the society's knowledge depends on the production of new knowledge, its transmission through education and training, its dissemination through information and communication technologies, and on its use through new industrial processes or services. Joining that relevance to *campi* extension and the university community dimension, the quality of life in university *campi* became a critical factor for management purposes.

In addition, there is a consensus about the fact that Portuguese Universities are leaving a period of continuous building growth and incoming in a cycle of stabilisation and consolidation. The demand tends to be satisfied. So, a new process shall emerge where the physical expansion will be substituted by an increase of quality.

Therefore, the main objective of the work presented in this paper is to implement an information system to evaluate and monitor the university campi quality of life. The system embodies two main functions: to inform, allowing any user to know how the quality of life on campus has evolved; and to be a decision support tool, mainly for facilities planning and management, getting a global quality of life according to the users' perception, taking advantages of the users' participation, through the integration of individual evaluations.

2 Motivation

Along the last two decades, Portuguese Universities have been making a strong effort in facilities investment. This was the result of an assumed policy of continued growth. It is agreed that the growing cycle will shortly achieve its limit, as all the initially foreseen valencies are installed, and an increasing offer is not expected due to the predictable demand reduction. The admissible growth will be necessarily focused on the creation of last valencies not yet contemplated and on the demand of new targets, namely at the level of postgraduate and continuing education.

Through growth consolidation of the existent projects, a process, where the dimension increase will give place to quality improvement, must emerge. The quality of teaching and investigation projects also relies on the quality of the spaces where they are developed. Those spaces can be buildings, with their classrooms, laboratories, and services or exterior spaces on the campi, leisure facilities, or traffic and parking conditions.

From that point of view, two approaches can be considered for the management of physical infrastructures: investments in infrastructures and buildings; and the campus quality of life. The construction effort was not always followed by qualitative measures that could promote a balanced liveability to thousands of students, teachers, investigators, staffs and visitors who daily spend many hours of their life in university campi.

Besides the obvious needs associated to their specific activities, those users aspire to a healthy and secure milieu, with a good and comfortable architectonic environment, with appropriated and well located facilities, with good mobility and accessibility levels,

etc. In short, they aspire to a University Campus with quality of life. In this way, Darus *et al.* [3] argue that in a sustainable model the space needs to be developed as a multifunction space to serve the main purpose of the campus. Also, they refer that the quality of life in campus is associated with the increase of the level of satisfaction and the facilities and amenities provided for the campus community. Among other components that are seriously considered are the relationship between several main activities, facilities and amenities in campus essential features, e.g., academic, research, administration, sport, recreational and private spaces.

3 Methodology

In spite of the known difficulties to find a universal definition of the quality of life in urban spaces, there is some consensus concerning the approach conducing to its conceptualisation. In this context, and without depreciating the discussion about the conceptual and qualitative aspects, the development of evaluation and monitoring tools to analyse the quality of life degree provided to campi users is seen as relevant.

The first step of the methodology approach is the identification of a set of quality of life dimensions, which is related to aspects of the campi liveability ([9], [10]). This can be done by using a previously defined "standard" list and gathering the opinion of a set of users (directly or through a representation scheme). The result should be the characterisation of these dimensions by an exhaustive number of indicators in order to portray the quality of life in the campus (QIC). As indicators can also be used for the dimensions' evaluation and monitoring, it is possible to conceive a system that contributes to the decision making in the campus' management.

3.1 Quality of Life in Campus - QIC Evaluation model

As in a small city, the liveability in a university campus is conditioned by many factors, such as the environmental conditions, mobility, accessibility to services and work places, and social conditions. Then, it is understandable that a university campus can be seen as an urban space. This idea is reinforced when considering the definition of city given by Merlin [8]: "a reunion of men, in a favourable area, to impel collective activities; a place for people, goods, capitals, ideas and information exchange, being simultaneously a framework, a motor and the result of human activities" (free translation). For that reason, the methodology exposed by Mendes [7] and implemented in several previous works of the author

([5], [6], [7]) was adopted for the Evaluation of the Quality of Life in University Campus. With the necessary adaptations, the following steps were proposed as a framework for the QIC Evaluation model:

- a) identify the dimensions to be considered in the evaluation of the QIC;
- b) establish a system of weights for the dimensions, through direct inquiry to the users, groups of interest or decision-makers;
- c) identify/build the set of indicators that characterises each one of the dimensions considered. This process is essentially based on the judgement of the investigator about the relevance of the indicators, since its adoption is usually conditioned by the availability of information;
- d) establish a scoring scale for the evaluation of the properly normalised indicators allowing their aggregation;
- e) establish a system of weights for the indicators. The weights attributed to the several indicators, inside each dimension, should be essentially based on the judgement of the investigator, due to the specificity of the indicators;
- f) establish each indicators aggregation rules, inside each dimension;
- g) establish the dimension aggregation rules.

Moreover, besides the identification of QIC dimensions and indicators, users should participate in the evaluation model definition and, periodically, in the monitoring of results. Globally, Fig. 1 describes the sequence followed by the definition, evaluation and monitoring process.

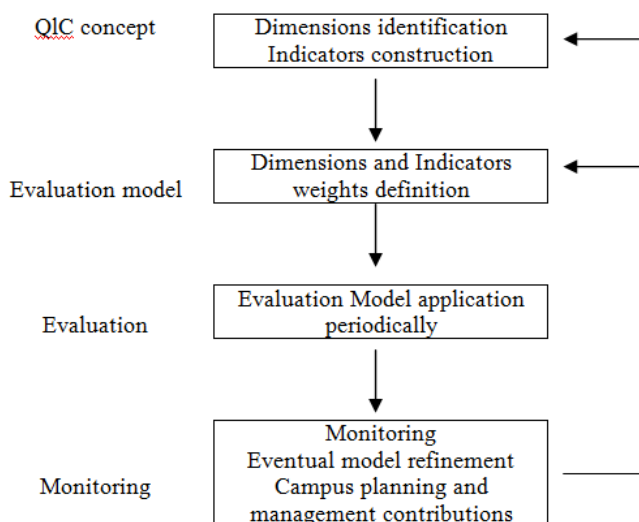


Fig. 1 – QIC definition, evaluation and monitoring process

This exercise only makes sense if, besides involving the users, it results in contributions for the campus planning and management. For each loop, a report

about the “State of the Campus” should be produced, including the indicators evaluation, where it will be possible to identify the imbalance and deficit of the global quality of life, as well as for each identified dimensions used in the analysis.

3.1.1 Indicators

As the objective was to evaluate and monitor the Quality of Life on campus, five dimensions were identified as appropriate for the study [10]: Environment, Mobility and Parking, Safety, Urban Space, and Services. Then, each dimension was characterised by the construction of a list of relevant indicators for each one. As the list was getting longer, the introduction of an intermediate grouping level was considered adequate: themes were introduced as dimensions sub items, creating smaller groups of indicators (Table 1 and 2a to 2e, adapted from [9]).

Table 1. *QIC Dimensions and Themes*

<i>Dimensions</i>	<i>Themes</i>
(1) Environment	(1.1) Environmental noise
	(1.2) Air quality
	(1.3) Waste management
(2) Mobility and parking	(2.1) Campus accessibility level
	(2.2) Campus accessibility level for handicapped people
	(2.3) Internal road network
	(2.4) Internal pedestrian network
	(2.5) Pedestrian accessibility ratio
	(2.6) Handicapped people accessibility ratio
	(2.7) Parking offer
	(2.8) Public transport
	(2.9) Service level of the axis campus-city
(3) Safety	(3.1) Crimes in campus
	(3.2) Campus surveillance
	(3.3) Fire fighting
	(3.4) Evacuation exercises
(4) Urban space	(4.1) Functional zoning
	(4.2) Urban furniture
	(4.3) Internal signalling
	(4.4) Campus works
(5) Support services	(5.1) Food and drinks
	(5.2) Shopping
	(5.3) Services
	(5.4) Leisure and culture
	(5.5) Sports

The inclusion of this new grouping level showed some benefits. On one hand, when listing and selecting indicators to be considered in the

dimensions characterisation, it helped to better define the extent of the task, delineating sub-contexts of the quality of life to be described. On the other hand, when developing the evaluation process, this layered structure for indicators grouping could also be replicated in tasks to be performed by the users, such as the selection of indicators and weights assignment operations, and even in the calculation process, when combining values to obtain the desired indexes.

Table 2a. *QIC Indicators of the Environment Dimension*

<i>(1.1) Environmental noise</i>
Average diurnal Leq(A) at central points
Diurnal Leq(A) distribution map
<i>(1.2) Air quality</i>
Average of particulate matter at central points
Particulate matter distribution at central points
Average concentration of volatile organic compound at central points
Concentration of volatile organic compound distribution map
Average concentration of NO _x at central points
Concentration of NO _x distribution map
Average concentration of CO at central points
Concentration of CO distribution map
<i>(1.3) Waste management</i>
Total number of litter bins
idem, per hectare
Litter bins distribution map
Map of distances to the nearest litter
Total number of recycle bins
idem, per hectare
Recycle containers distribution map
Distances to the nearest recycling container map

Table 2b. *QIC Indicators of the Mobility and Parking dimension*

<i>(2.1) Campus accessibility level</i>
Weighted sum of distances to key-destinations
Distribution Map of accessibility levels measured by the distances to key-destinations
<i>(2.2) Campus accessibility level for handicapped people</i>
Weighted sum of distances to key-destinations, for handicapped people
Distribution Map of accessibility levels for handicapped people measured by the distances to key-destinations
<i>(2.3) Internal road network</i>
Total extent of roads
idem, per hectare
Road map
<i>(2.4) Internal pedestrian network</i>

Total extent of pedestrian paths
idem, per hectare
Pedestrian paths map
<i>(2.5) Pedestrian accessibility ratio</i>
Pedestrian paths extent /road network extent
<i>(2.6) Handicapped people accessibility ratio</i>
Paths extent for disabled people / road network extent
<i>(2.7) Parking offer</i>
Total number of parking spaces
idem, per 1000 users
Parking lots map
Number of spaces for disabled people
idem, per 1000 users
Number of restricted spaces
Number of unrestricted spaces
Number of pay parking spaces
<i>(2.8) Public transport</i>
Number of bus routes between campus and city centre, from 8am to 8pm
Number of bus routes between campus and university residence, from 8am to 8pm
<i>(2.9) Service level of the axis campus-city</i>
Physical dimensions service level indicator of the pedestrian path campus/city centre
Pedestrian environment service level indicator of the pedestrian path campus/city centre
Bicycles service level indicator of the path campus/city centre

Table 2c. *QIC Indicators of the Safety dimension*

<i>(3.1) Campus criminality</i>
Number of crime complaints against people on campus, per year
idem, by 1000 users
Number of crime complaints against goods on campus, per year
idem, per 1000 users
Map of crimes locations on campus
<i>(3.2) Campus surveillance</i>
Number of exterior video cameras on campus
idem, per hectare
Map of video cameras location on campus
<i>(3.3) Fire fighting</i>
Number of exterior fire-hydrants
idem, per hectare
idem, per 1000 m ² of construction (implantation)
Map of exterior fire-hydrants
<i>(3.4) Safety exercises</i>
Number of safety exercises per year

Table 2d. QIC Indicators of the Urban space dimension

(4.1) Functional zoning
Built area (implantation)
Built area (pavement)
Idem, per user
Built area percentage
Construction index
Usable green area
Idem, per user
Percentage of green area in open spaces
Green area in open spaces
Idem, per user
Area for road traffic
Idem, per user
Area percentage for road traffic
Parking area
Idem, per user
Area percentage for parking
Functional zoning map
Sky View Factor average at central
Sky View Factor distribution map
(4.2) Urban furniture
Number of public lighting fixtures
Idem, per hectare
Public lighting fixtures distribution map
Number of monuments/artistic pieces
Idem, per 1000 users
Monuments/artistic pieces distribution map
Number of pillar-box
Idem, per 1000 users
Pillar-box distribution map
Length of outdoor benches
Idem, per 1000 users
Outdoor benches distribution map
Number of trees
Idem, per hectare
Trees distribution map
(4.3) Internal signalling
Number of orientation outdoor maps
Idem, per hectare
Orientation outdoor maps distribution map
Number of outdoor signals
Idem, per hectare
Outdoor signals distribution map
(4.4) Campus works
Area under repairs weighted by time, per year
Area under repairs distribution map

Table 2e. QIC Indicators of the Support services dimension

(5.1) Food and drinks
Bar capacity (clients zone)
Idem per 1000 users
Restaurant capacity (clients zone)
Idem per 1000 users
Number of vending-machines
Idem per 1000 users
(5.2) Shopping
Area of newspapers and magazines kiosks
Idem, per 1000 users
Area of bookstore
Idem, per 1000 users
Area of other shops
Idem, per 1000 users
(5.3) Services
Area of travel agencies
Idem, per 1000 users
Area of banks
Idem, per 1000 users
Number of ATMs
Idem, per 1000 users
Number of public phones
Idem, per 1000 users
Medical Support
Percentage of wireless network coverage
Area of other services
Idem, per 1000 users
(5.4) Leisure and culture
Number of places in auditorium (with capacity over 100 places)
Idem, per 1000 users
Number of cultural events by year
Idem, per 1000 users
Number of sport events by year
Idem, per 1000 users
(5.5) Sports
Area of indoor sports facilities
Idem, per 1000 users
Area of outdoor sports facilities
Idem, per 1000 users
Number of available sport modalities
Number of registered practising users
Percentage of registered practising users

3.1.2 Global QIC index

To get a global QIC index, it is necessary to find a way to combine the meaning of the indicators values. The calculation of the global QIC will reflect the grouping structure adopted for indicators. It means that indicators are combined at the theme level, themes indexes are combined at the dimension level, and finally, the global index results from the dimensions indexes combination.

Denoting the standardised value of an indicator i of a theme t by x_i^t , and w_i^t as its weight, a theme QIC index (S_t) is given by equation (1):

$$S_t = \sum_i^n w_i^t x_i^t \quad (1)$$

Equation (1) is essentially a Weighted Linear Combination, one of the aggregation procedures available in the context of multicriteria evaluation [14].

A very important component of a multicriteria evaluation model concerns the priorities attached to the various criteria, i.e. the values of the weights in equation (1). The objective of developing weights is to quantify the relative importance of criteria to one another, in terms of their contribution to an overall index. This detail is highlighted by Cheng *et al.* [1], because to evaluate decision alternatives in a new and complex problem setting often involves subjective evaluation by a group of decision makers with respect to a set of qualitative criteria.

Using the same approach as for the calculation of the themes indexes, a dimension QIC index (S_d) can be calculated by equation (2), where w_t^d denotes a theme weight and S_t^d a theme QIC index (see equation 1):

$$S_d = \sum_t^{n_d} w_t^d S_t^d \quad (2)$$

Finally, the global QIC index (S) is achieved by equation (3), where S_d is a dimension QIC index (see equation 2) and w_d its respective weight:

$$S = \sum_d^n w_d S_d \quad (3)$$

Figure 2 illustrates the construction structure of the global index, showing the sequential aggregation of values, starting from the base (the normalised value of indicators), going through themes indexes and dimension indexes, and finally achieving the global index calculation.

As indicators are measured in different scales, it is necessary to standardise their values before aggregation, i.e. all values must be reported to a common scale to allow their integration in subsequent operations, for instance, equation (1).

As one of the main purposes of this work is to evaluate the evolution of the QIC, the adopted standardisation process of indicators values is the result of comparing values to be normalised to those of a reference year. So, all the values of the reference year are established as the standard value, in this case the value 100. The values of the year to be evaluated are compared to original values and standardised values are calculated. The evolution of an indicator is measured through the comparison between the obtained standardised value and the value 100 (standard value). For instance, when an indicator has a positive contribution to QIC (i.e. its value increase also means a QIC improvement), we can say that an indicator as evolve positively when its standardised value is greater than 100. If an indicator is classified as having a negative contribution (i.e. its value increase means a QIC regression), then its standardised value will be greater than 100 (positive evolution) when its value is smaller than the one from the base year.

To avoid that standardisation could result in virtually infinite values, a limit value to positive contribution should be established. This limit value represents a value that indicates when a maximum positive contribution is achieved, i.e. the standardisation of any value greater than the limit will result in a same standardised value for the limit. For a more detailed explanation, see [9].

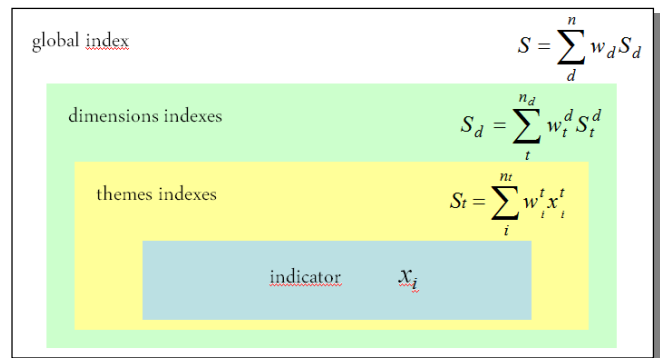


Fig. 2 – Global index construction structure

3.2 QIC System structure

A system containing four major components was idealised (Fig. 3). These components are a database subsystem, a models subsystem, a reports creator and an interface with the community.

The database subsystem includes a database (DB) that stores all the relevant data for the problem, as well as their description (metadata). All data accesses are made through a Database Management System (DBMS). The models database subsystem is dedicated to the management, maintenance and operation of models. It integrates a Models Base (MB) for storage and a Models Management System (MMS) manages the operations on the models base. The reports creator contains all the necessary procedures and tools for the presentation of results, showing the information in tabulate or graphical form.

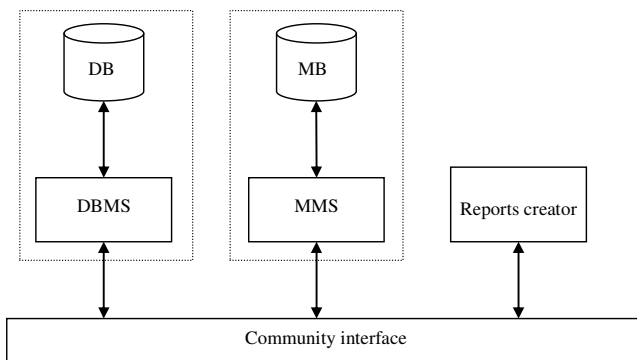


Fig. 3 – Components of the QIC System structure

The interface with the community is a subsystem that allows, in a transparent manner, interaction and operation with the remaining subsystems. Users can participate in the process and take advantages of the available functions, without however being required extended computer skills. For that reason the interface should be based on a well known working environment and with which computer users are more familiarised: the internet browser was elected. Also with the aim of making the interaction with the system as simple as possible, users should only be asked to do basic actions, such as inserting values, selecting items or clicking on buttons to initiate new actions, tasks that are very common when using a web browser. Furthermore, Tang [12] argues that the web page interface is often one of the key factors that determines the browsers to stay or to leave.

For that reason, we recommend the inclusion of wizards to simplify and guide users' actions. This is a way of interaction that guides the user through a process. This guidance can be made by providing the steps that the user should follow. The aim is to reach the end of the task, performing simple actions and also reducing as much as possible users' interventions. The adoption of wizards is considered appropriated in order to make the system more appealing and accessible to users, for it is a way to promote the community's participation. Another goal

of the appliance of this type of interface is also to minimise mistakes when gathering useful and essential information that would result in incorrect subsequent analyses. This is in fact a concern associated to the system developed, since one of its critical processes is the collection of individual evaluations from members of the academic community.

In the next two subsections, two recommendations in the system implementation are made: include wizards to simplify users' actions; and also enable users to freely navigate through the available information. These two aspects can greatly contribute to the success of a system.

3.2.1 Wizards

A wizard is a way of interaction that guides the user through a process. This guidance can be made by sequentially providing some steps that the user should follow, with the aim at reaching the end of the process, simplifying actions to be taken and also reducing as much as possible user's interventions. The adoption of wizards is considered appropriated in order to turn the system more appealing and accessible to users, for it is a way to promote the community's participation. On the other hand, the appliance of this type of interface also aims at minimising mistakes when gathering useful and essential information that would result in incorrect subsequent analyses.

Due to the fact that the collection of individual evaluations from members of the academic community is a critical process of the system, the construction of a wizard that guides participants through the evaluation steps can be considered essential to attain the expected results.

In that kind of guided process, it is important to maintain the interface user-friendly to keep users tasks as simple as possible. With that purpose graphical elements that have an intuitive usage are recommended.

For instance, when selecting indicators, checkboxes can be a good solution, showing that an indicator is selected when a checkmark is drawn in front, or that an indicator will not be considered when no checkmark appears. When it is asked to choose the indicators weights, radio buttons can be adequate for the task. Sequential values can be provided and the user will only have to click on the one he decides to choose.

3.2.2 Non-standard processes

Non-standard processes will allow users to freely consult and collect information, i.e. without having to follow any wizard instruction. A user who accesses to

the system will be able to explore all the available resources, without having to follow previous defined steps and iterations. So, navigation must be simplified. The use of menus and options integrated in a global structure can globally transform more intuitive and simple accesses. Keeping that in mind, providing the campus QIC current state, through the consultation of values referring to the eligible indicators in evaluation of the quality of life variation, will certainly improve the information function of the system. Besides that, this description can include several maps that illustrate some indicators, namely when an indicator is represented by none of the discrete values (for example, areas).

Figures 4 and 5 show two examples of maps that the system is intended to provide in a way to illustrate the state of some considered indicators. Figure 4 presents the distances to the nearest recycling container using buffers of 100 meters.

Figure 5 is the result of an evaluation process of accessibility to key-destinations using a network of pedestrian paths. All maps and subsequent calculation were developed within a GIS environment.

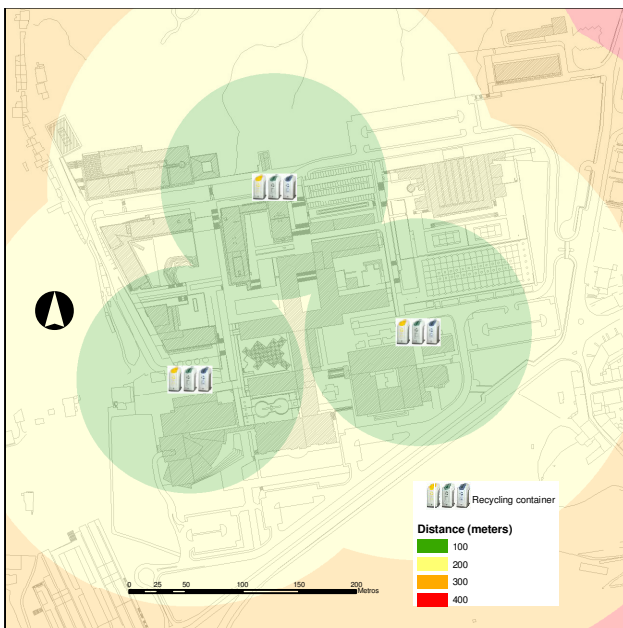


Fig. 4 – Map of distances to the nearest recycling container

4 A case study: Gualtar Campus of the University of Minho, Portugal

In Portugal, universities work in a context where the availability of funding resources is limited and depends on the ability of attracting students. University Campus management and planning will benefit from any kind of support that can supply relevant information, in order to contribute to better decision making when searching the best solutions

for the managed institution, as well as for all the users. In this context, a decision support system can be very useful.

The methodology presented in the previous section was implemented and tested as a case study developed at the Gualtar Campus of the University of Minho, Braga, Portugal. The Campus is located in a peripheral area of the city of Braga, and occupies an area of twelve hectares. The community of the Campus has about 13100 users, being 12000 students, 800 professors (including lecturers) and 300 staff employees. The buildings support academic activities, congregate Schools and Institutes, three Classroom Complexes and several buildings for services, such as the Library, the Computational Centre, the Academic Services, the Sports Complex, etc.

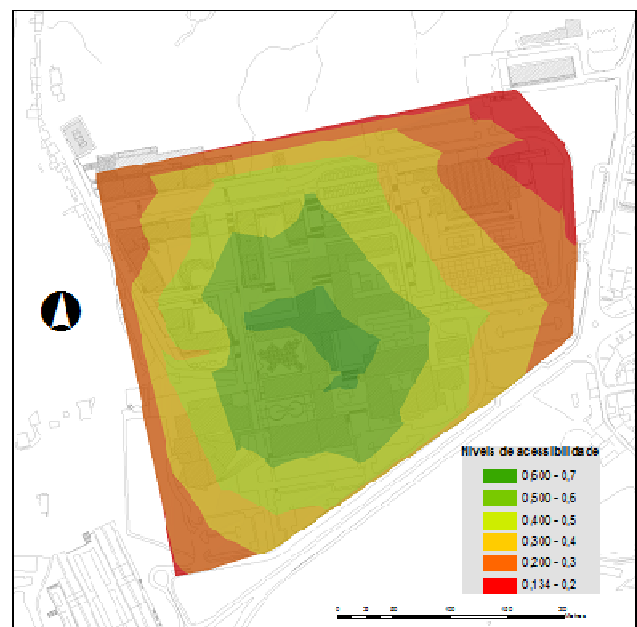


Fig. 5 – Distribution Map of accessibility levels measured by the distances to key-destinations

4.1 Indicators, themes and dimensions weights

A panel of 45 students, 8 teachers and 10 members of the administrative staff that intended to represent the different groups of users existing in the academic community was asked to set weights to dimensions, themes and indicators. In Table 3, obtained values can be seen. The Community value is the aggregation of the other three values (groups of users), proportionally to their relative importance. It can also be observed that the several groups have assigned different levels to the dimensions.

Table 3. Dimension weights by users' groups

	Students	Teachers	Staffs	Community
Environment	0.206	0.206	0.218	0.208
Parking and mobility	0.197	0.212	0.194	0.198
Safety	0.206	0.230	0.218	0.211
Urban space	0.181	0.164	0.181	0.179
Support services	0.210	0.188	0.190	0.204

4.2 QIC evaluation scenario

To validate the model and the system, a scenario for 2007 was created. It consists of updating the values of several indicators that intend to reflect possible changes/interventions on campus. The considered possibilities were:

- i) installing a new recycling container to improve actual coverage (to reduce the distances) of the campus. It implies the assignment of a new value to indicators total number of recycling containers and total number of recycling containers per hectare;
 - ii) increasing to 14 the number of daily buses running between the campus and the city centre, from 8am to 8pm;
 - iii) installing 6 new exterior fire hydrants to reinforce the existent net. The affected indicators are a number of exterior fire hydrants, a number of exterior fire hydrants per hectare and a number of exterior fire hydrants per 1000 m² of construction (implantation);
 - iv) planting 50 new trees, trying to improve the physical and natural environment of the campus, the indicators total number of trees and total number of trees per hectare received values that reflect this change;
 - v) constructing the new building announced in the UMDicas newspaper (published by the university social services), which will include a new sports complex, a cardio-fitness room and a medical centre; it affects several indicators, distributed on more than one dimension;
 - vi) installing another Automatic Teller Machine (ATM), that could improve the coverage of this type of equipments, namely in the sports complex where the offered services require payments;
 - vii) increasing the medical support to 10 hours, making it available from Monday to Friday, even for short periods of 2 hours;
- improving the wireless network coverage, especially outside buildings that is for now only available indirectly (only when in range of inside buildings network coverage).

4.3 QIC individual evaluations

As referred in section 4.1, the panel members have provided their preferences about indicators to be selected and their weights to be used in the QIC variation evaluation. Moreover, this task was framed into a process of individual evaluation. So, each participant is able to accomplish a personal evaluation using his/her preferences and obtaining at the end of the line the result of choices made. For instance, Figure 6 shows the final webpage that presents the results obtained by a participant. It can be seen that the value of the QIC variation index is presented, as well as a bar chart showing the profile of the index. This profile allows us to read in which way each dimension has contributed to the global index.

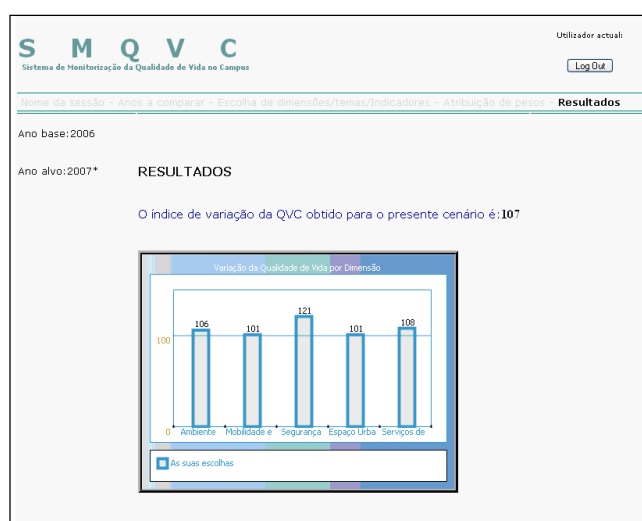


Fig.6 – Individual evaluation page result

The neutral value (100) is shown as a horizontal line. When a bar is over the line, it means that the dimension has got a positive evolution (index value greater than 100) and contributed to the global index positively, and, conversely, when a bar is under the line, it means that the dimension has got a negative evolution and has also contributed negatively to the global index.

4.4 QIC evaluation results

The last step of the quality of life variation evaluation process consists of calculating indexes for each group. This task implies the application of the weights derived from the users' participation through the calculation process described in section 2.1.2. Table 4 shows indexes obtained for each campus user group.

Table 4. Quality of life variation indexes by group

Group	Index
Students	107.4
Professors	108.0
Staff	107.7
Community	107.5

As it can be seen, the implementation of the evaluated scenario could origin a positive variation of the quality of life for all the groups, i.e. the obtained indexes are all higher than 100 (base value). Presented values do not differ much. This can be justified by the fact that users assigned weights in a quite similar manner. Even short, the biggest difference is found between the students index and professors one. This gap happened because the professor group took some different options when assigning weights in comparison to other groups. Using the scenario previously described, Table 5 shows how the variation of each affected indicators is numerically translated by the normalisation process. Only these indicators are shown, although the remainders were unchanged, i.e., their normalised value is equal to 100 (reference value).

Table 5. Scenario indicators normalised values

Total number of recycling containers	133
Total number of recycling containers, per hectare	135
Number of daily buses running between the campus and the city centre (8am to 8pm)	121
Number of exterior fire hydrants	143
Number of exterior fire hydrants, per hectare	142
Number of exterior fire hydrants, per 1000 m2 of construction (implantation)	140
Built area (implantation)	98
Built area (pavements)	99
Built area (pavements), per user	99
Percentage of built area	96
Number of trees	108
Number of trees, per hectare	107
Number of ATMs	120
Number of ATMs, per 1000 users	118
Percentage of wireless network coverage	167
Medical support	250
Area of indoor sports facilities	122
Area of indoor sports facilities, per 1000 users	122
Area of outdoor sports facilities	92
Area of outdoor sports facilities, per 1000 users	92

The system also provides graphical results. Charts show the quality of life variation by dimension. With

that kind of representation, it is possible to observe how each dimension has contributed to final indexes. For example, Figure 7 shows that Environment dimension got a higher value, more than 100 for each group. It means that the QIC variation is always positive, i.e., in any case, this dimension contributed positively to the global index. Looking at the results of each group, we can also see that they were not quite similar, because the value for the Professors' group is the only one that is different.

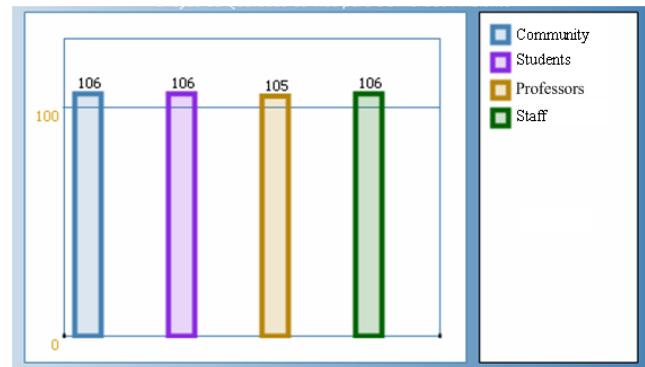


Fig. 7 – Quality of life variation for the Environment Dimension

Analysing the graphs of the other dimensions - see [9], the differences between groups' indexes values, when they exist, were never higher than one positive point. When comparing those values the reference indexes (100), the urban space dimension and the mobility and parking dimension presented a variation which was not higher than one point. The others revealed a more significant variation with a difference of five, six or seven points. However, the safety dimension got results that are beyond those, presenting a variation of twenty-two points for Professors and twenty-three for the other groups.

5 Conclusion

Basically, the presented model aims at determining a global index of the Quality of Life in Campus (QIC) variation, comparing different moments in time. Directly comparing a set of indicators, this index allows us to evaluate how QIC has evolved in general terms. If results are analysed at the indicator level, i.e. studying the variations of each indicator, it is possible to identify which ones have more significantly contributed to the QIC variation trend. That kind of analysis can also be conducted to a theme level, as well as to a dimension level. Moreover, each individual's participation and a few users' profile data were stored in the database, enabling the calculation process of QIC variation indexes by users' groups. In other words, the system's outputs can be used to analyse the quality of life variation profile.

The system also provides another functionality that allows measuring the impact on QIC of future interventions through the creation and evaluation of scenarios (assignment to indicators of new hypothetical values). Providing these functions, the system can effectively work as a decision support tool for campus planning and management, when searching for solutions that meet the users needs. Furthermore, as the community involvement is important, a special attention was given to the system's interface design. All required actions were kept as simple as possible and a user-friendly interface was developed, using web browsers as working environment.

By using a base year when calculating general indexes of QIC variation it was possible to collect information that would be useful for temporal analysis. So, it is possible to compare several years to a common base year, showing obtained indexes and allowing the search for a tendency. For a time period where data of different years are available, a QIC variation evaluation can be carried out using successively each year as a base year. The variation will be calculated when comparing to the first following year in the chronological order. Indexes refer to comparisons of pairs of years that cover the whole studied period.

Finally, the system was also conceived with the aim of completing an informative function: users may use it to build up their own ad-hoc analysis. Through the indicators, many data were gathered, processed and stored into the system's database. Using the web browser interface, information that before was unavailable or available but diffused can now be accessed in a user-friendly environment. As long as it was required the item or items were better understood graphically, maps were created using a geographical information system, improving the readability of the information.

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