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THE CREATION OF “QUESTIONS BANK” AND INTRODUCTION OF 2.0. EXAMINATION SESSION

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In the Institute of American Studies and Polish Diaspora Jagiellonian University, with the support of the Distance Learning Centre at the Jagiellonian University was introduced an innovative method of examination based on empowering the students.

During the 2014 session, the students were invited to create test questions. Accepted by the lecturer questions were used on the exam. Extensive “Questions Bank” may be used in subsequent examinations 2.0.

The authors of the paper present practical advice on how to prepare and carry out such an examination. They share *know how* of practical suggestions from pedagogical to technical aspect of moving from teaching to learning while using the idea of Questions Bank. They discuss the impact on the motivation and creativity of students, the principles of achievement and assessment, methods of verifying the content of the questions and technical measures to make questions and hindering cheating.

The use of innovative methods of preparing and conducting the exam based on the Questions Bank had a positive impact on the mobilization and involvement of students, which resulted in a very good performance evaluation questionnaires of the lecturer.

Keywords: e-learning, exam, assessment, teaching, motivation, mobilization

1. From teaching to learning

The idea of “Questions Bank” locates itself in the broader framework of changing education from teaching to learning. The Questions Bank project is an outcome of the second *Education Quality Week* at the Jagiellonian University (UJ) held on December 2-6, 2013. The event is organized annually by the Section Analysis Quality of Education, UJ (Sekcja Analiz Jakości Kształcenia, UJ). The five days-long event is addressed to all members of the Jagiellonian University community. Its aim is to increase awareness of measures taken to improve the quality of education. It is a forum for the exchange of good practices. [1]

In 2013 the second day of the event was dedicated to workshops for academic teachers. One of the workshops focuses on *how to create tests well, including tests on the University platform Pegasus*. This was the place where the authors of this article met for the very first time: Andrzej Filip (from *the Distance Learning Centre UJ – Centrum Zdalnego Nauczania UJ*) was one of the workshop speakers, while Piotr Drag was a participant on the side of academic teachers.

The aim of the workshop was quite different from the final product “Questions Bank”. This was the description of the workshop:

“The written knowledge test is a method of examining students, which is of particular use in the conduct of distance education. The workshop will enable participants to gain knowledge about the principles of building test forms. In addition to the teaching of the theory, participants will also have the chance to see how to prepare for a test on the university e-learning platform Pegasus” [2].

The innovation of the “Questions Bank” project is to invite students to the process of creating test questions.

2. When is a student learning the most?

It seems that the answer to this question is rather obvious. The students learn the most before the events that will test their knowledge. There is a certain rule: more important examination students face then their learning preparation efforts tend to be more intense. According to this rule - students learn the most - right before the final exam. The aim of the exam is to test the knowledge of students by a professor. The preparation for an exam is based on the student testing his knowledge that he was able to gain while taking a course. In this way the test is not only a method of assessment intended to measure a test-taker’s knowledge, but could also be taken as an effective way to learn. In order for this to happen a teacher needs to empower his students or rather develop in them the ability of critical thinking and asking the right questions.

The 2013/14 academic year was the very first year of teaching in the new academic environment for dr. Piotr Drag. In the beginning of the year he was

offered a position, that of an academic teacher at the Institute of American Studies and Polish Diaspora in the Faculty of International and Political Studies at the Jagiellonian University. Dr. Drag has international academic credentials. As an Ox-bridge he was exposed to learning the tutorial method from the best sources. Besides the European and American Universities where he taught he also had a chance to study at the Hebrew University in Jerusalem. There he was stunned by the sheer intensity with which the students grappled with texts and were not afraid to raise questions. Sometimes he would hear in the classroom the encouraging comment of teachers in Yiddish “du fregst a gutte kashe” (you raise a good objection). Dr. Drag tried to introduce the same attitude among his students. In 2013/14 dr. Drag taught classes entitled: *Migration* (lectures + exercise – 60 hour long course) for stationary and not-stationary students and *The ethnic issues in Polish History* just for stationary students (lectures + exercise – 60 hour long course). All of his students participated in the process of creating the Questions Bank. In order to encourage his students to learn by asking questions, dr. Drag used the story of a Nobel prize winner in physics from 1944 - Isidor Isaac Rabi.

3. 'Izzy, Did You Ask a Good Question Today?'

The story of Isidor Isaac Rabi was a perfect story illustrating not only the method implemented in the creation of the Questions Bank but it was also a very good example for issues taught during the class on *Migration* and *The ethnic issues in Polish History*. Our champion of asking questions, the title Izzy was a child from an immigrant Jewish family who left Galicia (Rymanowa near Krosno) when he was one year old and eventually settled down in Brooklyn, New York. The American Dream of Isidor Rabi came true in his academic career. In addition to his Nobel award, his work contributed to the invention of nuclear magnetic resonance spectroscopy, radar, the nuclear bomb, the laser and the atomic clock. Once he was asked, "Why did you become a scientist rather than a doctor, a lawyer or a businessman, like the other immigrant kids in your neighborhood?" His father had been a tailor and a grocery store owner in Brooklyn [3]. Isidor Isaac Rabi responded that this happened because of his Yiddishe Momme. “My mother made me a scientist without ever intending it. Every other Jewish mother in Brooklyn would ask her child after school: ‘So? Did you learn anything today?’ But not my mother. She always asked me a different question. ‘**Izzy,**’ she would say, ‘**did you ask a good question today?**’ That difference – asking good questions – made me become a scientist!” [4].

Although Sheindel Rabi, dr. Rabi’s mother had not received the benefits of education beyond perhaps grammar school, her question testified that those who ask good questions are those who will not only survive, but who will prevail.

Therefore, her question has served as an inspiration and as a credo for the students who participated in creating Questions Bank [5].

The secret code to incorporate one's questions to the Questions Bank was the good mastery of the material, since only good mastery and an interest in a particular subject enables one to ask the right questions.

4. Technical and organizational overview

Theoretically the 'question bank' assignment could be done as a 'pen and paper' exercise where students submit all the questions on paper and the teacher selects them and incorporates them into a test paper. But it would be impractical since it would take at least the same amount of time as using modern IT tools (and most likely disproportionately more) and would also prevent one from creating randomized tests (with different questions set for each student).

The best way to do so smoothly was to use the Moodle virtual learning environment. Moodle is a well-known platform for course material delivery, but it is sometimes forgotten that Moodle was created with a social-constructivism approach in mind [6]. Using this approach, students can participate in the content creation process. This is possible thanks to the *Locally assigned roles* function. This function allows one to give each student a *Teacher* role for a selected activity module.

For the purposes of the 'question bank' assignment, a separated quiz activity module was created for every student, and thus each student was made a teacher in this quiz module (more will be covered in *Technical details* part of this article). This gave students the possibility of creating new questions and editing quiz properties, but they were restricted to their own quiz module – other students' modules were hidden from them.

During the assignment each student had to create 10 questions which were obligatory and up to 20 extra questions for bonus points. They had 4 weeks to create their own question set.

In order to make the question creation process smooth, there was a short (circa one-hour) training showing students how to create questions. This was done to help students with less advanced computer skills, but in the future we will create a dedicated on-line training material for the 'question bank' assignment.

During the question creation process students were obliged to provide references for every question they made. References in the form of bibliographical information and a photo of each particular page were inserted in the *General feedback* field for each question (*General feedback* is information displayed when a question is answered, but it can be hidden at the teacher's discretion). Thanks to the photo-bibliography, the teacher was quickly able to verify the value of each

question. After 4 weeks students were deprived of the *Teacher* role for their quiz, which meant that they could not change anything. Then a teacher checked all the questions and chose appropriate questions for a subsequent test. Only good, essential questions with proper references were selected.

All questions selected by the teacher were put to a categorized question bank. Roughly half of the questions were shown to the students in an unmarked, free-access quiz module, giving them the possibility to partially prepare for the final test.

5. Technical details

5.1. The Question bank's creation process

All 'question bank' assignment activities were done on Moodle platform. For each student a separate quiz module was created. In order to make the process of quiz modules creation smooth, one quiz was created and it was cloned using *Duplicate* function. The quiz module used default setup except:

- *Layout > New page* was set to *Never, all question on one page* – this made preview and correction easier.
- *Question behaviour >* was set to *Adaptive mode (no penalties)* – this allowed one to check particular questions without submitting the whole quiz.

When quiz modules were duplicated, they were renamed using the students' name and surname, and for each quiz the *Locally assigned roles* function was used to give each student *Teacher* role and permissions.

Finally, all quiz modules were hidden. This made them visible only for the teacher and student with the *Teacher* role assigned for this particular quiz. Students could not see other quizzes.

Students had access to multiple question types offered by Moodle platform (both built-in and offered by plug-ins). The most popular question types were:

- multiple choice,
- multiple answer,
- true/false,
- drag and drop matching [7],
- drag and drop into text [8],
- hotspot – show particular thing on the image (both *Drag and drop onto image* [9] and *Drag and drop markers* [10] questions were used).

References in the form of bibliographical information and the photo of each page were inserted in the *General feedback* field for each question. This is a quite essential part of the method. It allows the teacher to quickly verify if the information regarding a particular question is appropriate, and to make a reference

to the books' list from the syllabus of the particular subject. Due to the wide-spread use of photo cameras nowadays in numerous electronic devices, such as: phones/smartphones/tablets, etc., this step is very easy for students and it makes the teacher's work much faster. In fact, the evaluation process regarding question value based on its bibliographical reference and photo, could be done without the opening of the particular book.

After the question creation period, all students were deprived of the locally assigned *Teacher* role which meant that they could neither see their quiz, nor edit questions anymore.

During the question selection process, the teacher selected good questions and moved them to a categorized question bank, assigning each question to particular categories. Moodle platform mechanics allow one to create flexible, multi-level categories for organizing the question bank.

Half of the questions were shown to students which allowed them to learn and get used to particular question types. They could even copy the questions, but considering the scale of the project (over 1200 questions), memorizing half of the question bank is not the optimal strategy for learning – it would be easier just to learn the course material rather than trying to memorize everything, especially when students knew that half of the questions are hidden.

Questions were shown in a large, *Adaptive mode* quiz module (*Adaptive mode* means that students can answer various questions) with *General feedback* displayed (which showed students the source so they knew which material they should use for learning).

5.2. Exam – goodbye cheating

According to Polish legal regulations all final exams should be conducted in a controlled environment which means that distance-learning exams are out of the question. Exams should be conducted at the university under teacher supervision. But using modern IT tools allows for a much stricter environment, where cheating is almost impossible. This is ensured by the following tools:

- Safe exam Browser (SEB) [11] – this is a special, free, dedicated internet browser which is meant for conducting on-line exams. SEB was installed on every computer. SEB prevents students from:
 - using the internet (except entering Moodle platform – starting URL is defined in setup file),
 - launching any software,
 - connecting USB devices and using DVDs,
 - closing SEB – it could only be closed by a secret key combination known only to the teacher,
 - using course materials – after a small Moodle layout customization all navigation can be hidden in SEB mode, meaning that after

starting the quiz, students are unable to view course material or even go to their profile (they could hide a Google link or other materials there). They can only finish the quiz.

Safe Exam Browser requires changing the Moodle platform setup – under *Site Administration > Development > Experimental* setting *Enable Safe Exam Browser integration* should be turned on.

- Proper exam quiz module setup:
 - *Extra restrictions on attempts > Browser security* set to *Require the use of Safe Exam Browser* meaning that only SEB users could attempt the quiz.
 - *Extra restrictions on attempts > Require network address* with the address of the exam room network (or with the addresses of particular machines) – if someone would like to receive help from someone outside the room (even using SEB), they would not be able to start the quiz, unless physically present in this particular room.
 - *Extra restrictions on attempts > Require password* for extra security (students were given the password when they started the quiz attempt).
 - *Layout > Navigation method* set to *Sequential* and *Layout > New Page* set to *Every 10 questions* which meant that students saw 10 questions at a time, and after marking responses and going further, they were unable to come back. This made using notes or asking others for help much more difficult.
 - *Timing > Time limit* was set to *60 minutes* for 140 questions which required quite fast responses (but it was perfectly enough for those who were prepared for the exam).
 - *Review options* were set to display *Marks* only to prevent students from sharing detailed responses with the next group. They were shown full feedback after exams were finished.
- Quiz randomization mechanics:
 - Questions were randomly selected from categories providing every student with different questions (but the same amount of questions from each subject).
 - In exam quiz module setup *Question behaviour > Shuffle within question* was set to *Yes*, providing the mixing of responses for each questions. This made watching the neighbour's display for answers much more tricky, because at a distance people tend to watch position, not a particular text, and since positions are mixed, using someone else's responses could lead to mistakes.

Finally, teacher supervision made other forms of cheating very risky. Together with the technical means of cheating prevention, randomized questions and a time limit (without the possibility of returning to previous questions) made cheating nearly impossible.

6. Exam – the numbers

There were 108 students who took part in the ‘questions bank’ assignment. After the assignment, 1283 questions were selected by the teacher for further use.

The exam consisted of 140 randomly selected questions, each marked for 0.5 points – for a total of 70 points. Other 30 points could be scored for preparing questions during the ‘questions bank’ assignment. Besides the 30 points for 10 obligatory questions, there was also a possibility to earn 10 extra points for bonus questions.

Students	Questions	
108	1283	
Exam time	Questions during exam	Points per question
60 minutes	140	0,5
Points for exam	Points for questions	
70	30	

Despite the fact that students had access to roughly half of the questions bank, the exam proved neither too easy, nor too difficult. The lowest score was 26.18 out of 70, and the highest was 63.17. All students managed to finish within the 60-minute time limit. The fastest solution took just 19 minutes and 23 seconds, and this was also one of the highest scores during the exam.

Lowest score	
26,18	
Highest score	Best time
63,17	19'23"
Max score	Time limit
70	60'

There were also interesting results in the post-assignment survey. The authors thought that students would consider this method good but too time consuming. During the survey, however, only 10 out of 46 students considered it too time consuming, 34 considered it good, and only 2 preferred just reading course material to the question creation activity.

Moreover, the increasing activity during classes resulted in an increased activity during the university-wide evaluation survey – 63.51% students took part in the survey compared to the 15.4% university average. The average mark for ‘classes quality’ was 4.9 out of 5, compared to the university average of 4.39, and the average mark for ‘teacher’ was 98 out of 100, compared to the university average of 85.

7. Ideas for the future

Preparing a ‘questions bank’ by the students is just one example how students can be engaged in the creation of different types of course material. There are many different activities depending on classes type and their computer skills.

One of the simplest ideas is to write short articles on particular subjects: like an event, person, concept, etc. Such articles can be used as course materials. Students can also create simple video-essays, combining Power-Point or Prezi presentations supplemented with audio (or audio/video) comments recorded with a screencasting software (like Techsmith Camtasia or something similar).

Students can also use built-in Moodle tools to create dictionaries, wiki-style knowledge bases, or a reference base containing bibliographical positions and links to useful sites and articles.

8. Summary

The innovation of the Questions Bank project was based on empowering students and giving them the role of a teacher. The excellence of the students’ performance stemmed from asking good questions, which is inseparably connected with a good mastery of the material. The typical pre-examination stress in the face of unknown questions that a teacher might ask during the exam was reduced, since a good part of the questions were known to students who were actually their authors. The pre-examination stress engine was directed towards the creativity of students. The motivating element of competition between students was introduced. All of these made the project very successful. Shifting from teaching to learning made the project very well received at the prestige conference *Virtual University 2014* held at the Warsaw University of Life Sciences – SGGW on 25-26.06.2014, as well as on the international level. Keen interest in the Questions Bank project

was shown by Dr. Thomas H. Bak from the University of Edinburgh, presently holding the position of Chair of the World Federation of Neurology. This shows that the Questions Bank project could be implemented by teachers and specialists of various sciences – those who know the value of asking a good question.

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THE USE OF SPATIAL DATA PROCESSING TOOLS FOR AIR QUALITY ASSESSMENTS - PRACTICAL EXAMPLES

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In this article the potential applications of GIS systems in the management of air quality are discussed. In particular two specific issues are described: determining the spatial representativeness of air quality monitoring stations and areas of standards exceedances. The methods using spatial and emission data, as well as, the results of measurements, i.e. Land Use Regression method and so-called Beta parameter method are presented. The first one is based on the regression models in which mentioned information may be treated as independent data and, as a result, we obtain information on the levels of pollutant concentrations in point and space. The second method involves the parameterization of the spatial characteristics selected on the basis of the monitoring and emission data. These methods can find practical application in the field of air quality monitoring, assessment and the preparation of a public web presentation.

Keywords: air quality, environmental monitoring, geographic information systems, spatial data processing, decision support systems

1. Introduction

Air pollution is one of the main environmental problems occurring in Poland and in other countries. In Poland, this problem affects mainly large urban areas, but also concentrations of polluting substances are in excess of the established standards can affect smaller cities and rural areas. Industrial installations, road transport and municipal-household sector (small heating plants and individual heating sys-

tems) are the sources of air pollution. Particulate matter PM10 or PM2.5 and benzo(a)pyrene and, in smaller range, ozone or nitrogen dioxide, can be treated as problematic pollutants whose concentrations exceed the applicable standards [1]. An increased concentrations of these substances can cause adverse health effects, both short-term as a result of exposure during episodic occurrence of smog situation, and as a result of long-term exposure.

In 2013 exceedances of the limit value for PM10 (based on daily averages) occurred in 36 out of the monitored 46 zones in which an air quality assessment is performed [1]. It is associated mainly with the emission from the sources of communal-residential sector (household heating systems using solid fuels, often old and not efficient, especially active in winter period). An allowed number of exceedance of the level $50 \mu\text{g}/\text{m}^3$ is 35, according to the Polish and European legislation. This standard is not achieved at many stations throughout the country, but in the south (region of Silesia and Lesser Poland) situation is the worst. Poland was reprimanded by the European Commission for its non-compliance and an infringement procedure was started at the European Court of Justice.

Various informatics systems are used for the purposes of air quality management at different levels European, national, regional and local. Assessment of air quality is an element of environmental management processes. Information systems are used, inter alia, for the collection, processing, visualization, transmission and reporting of various types of data and information, e.g. the results of measurements of pollutants concentrations or mathematical modeling. To the group of those systems we can include different types of systems and tools from the GIS family, from mobile applications or simple desktop applications to complex, multi-module systems for analysis and presentation, which use spatial databases, analyze information in real time and allow to work through an internet network (i.e. web-GIS).

2. Usage of spatial information processing in air quality management

2.1. Model of air quality management

The air quality assessment is one of the elements of environmental management. For the purposes of the analysis, including analysis the interplay between the environment and socio-economic activities, Driving forces - Pressures - State - Impact - Responses (DPSIR) framework is used. This approach can encourage and support decision-making processes, by pointing to clear steps in the causal chain of management. It has been adopted, e.g. by the European Environment Agency (EEA) and US Environmental Protection Agency (US EPA). It is extension of the Pressure - State - Response model developed by OECD and it has been applied to the organization of systems of indicators and statistics in relation to policy aims.

This model describes a dynamic situation, with attention for the various feedbacks in the system. By their nature, indicators take a snapshot picture of a constantly changing system, while the assessments that accompany the indicators can highlight the dynamic relations [2]. The existence of dynamic interrelations within a DPSIR framework makes it often a very complex web of many interacting factors. In many cases the change in the state of the environment or impacts has several causes, some of which may be immediate and of local origin, others may be exerting their influence on a continental or even global scale. Reductions in pressures often result from a mixture of policy responses and changes in various driving forces [3]. The framework is seen as giving a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future.

Information and communication technologies (ICT) may currently be used at each stage of the analysis and management of air quality. It includes, among others, the processing and analysis of the spatial information using GIS tools and systems. Fig. 1 shows the general scheme of the DPSIR model, while Table 1 gives brief definitions of individual elements of the model, along with examples of activities carried out with the use of GIS.

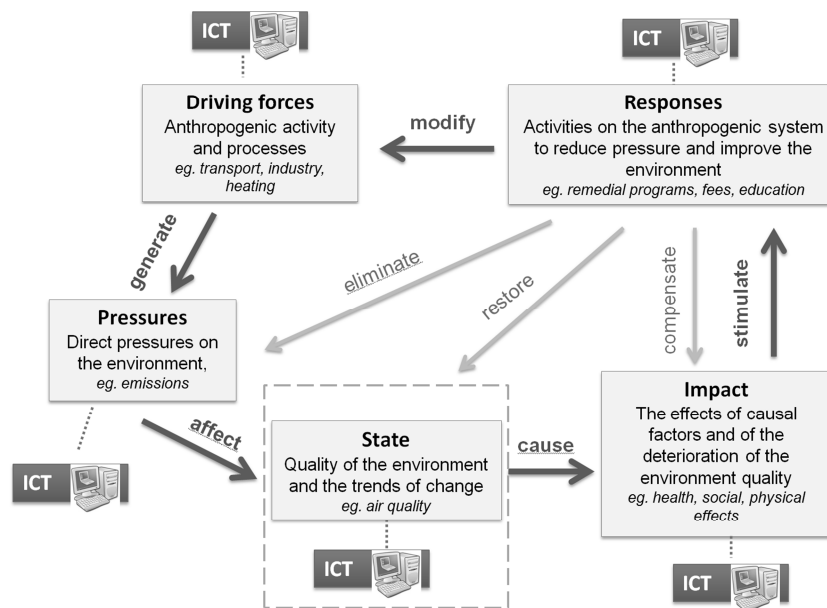


Figure 1. General schema of the DPSIR Framework
Source: own preparation on the basis of [2]

Table 1. An explanation of the levels of the DPSIR Framework with examples of application of GIS technologies

Level	Description	Examples
Driving forces	Human influences and activities which underpin environmental change (positively or negatively). The driving forces behind air quality change include increased burning of fossil fuels for transport, and industrial or domestic consumption of energy.	<ul style="list-style-type: none"> • Analysis of the spatial location of industrial plants • Analysis of the transport system and traffic distribution • Analysis of the structure and condition of the buildings (e.g. heat and energy demand)
Pressures	Direct or indirect pressures on the functionality and quality of the environmental system or resource, resulting from the driving forces, e.g. emissions of SO ₂ , NO _x , PM10 etc. constitute pressures on the natural atmospheric system.	<ul style="list-style-type: none"> • Analysis of the location of emission sources and spatial distributions of emissions • Emission inventory and modeling
State	Current status of the system or resources, in terms of quality of the environment and quantity or quality of resources, e.g. gaseous and particulate concentrations measured at particular stations - the state of air quality (national, regional, local, urban, etc.).	<ul style="list-style-type: none"> • Monitoring network management • Analysis of the results of measurements and mathematical modeling, including the use of geostatistical methods • Decision support in the air quality assessment
Impact	Environmental effects/responses to pressures on the current state, e.g. human health impacts (welfare of human beings, increased incidence of respiratory disease) and higher incidence of corrosion of infrastructure.	<ul style="list-style-type: none"> • Modelling and assessment of health risks
Responses	Responses to the pressures on the states and resultant impacts. Possible actions: <ul style="list-style-type: none"> • to mitigate, adapt to, or protect human induced negative impacts on the environment, • to halt or reverse environmental damage already inflicted, • to preserve and conserve natural resources. e.g. implementation of air quality standards, monitoring of air quality, installation of clean-air technologies, changing of heating systems, limitation of traffic, a policy to change mode of transportation, e.g. from private cars to public etc.	<ul style="list-style-type: none"> • Forecasting and visualization of the effects of corrective measures • Public information and education - geoportals

Element "State" in Fig. 1 has been marked because the process of air quality assessment concerns mainly the diagnosis and description of its state. In addition, of course, it includes indicate the reasons of the described state (Pressures), and also shows the possible consequences - "Impact".

Under the current rules, relevant services and institutions use various types of data and information from the following sources in the frame of air quality assessment: measurements of air pollution concentration (automatic or laboratory), mathematical modeling of the pollutant distribution and objective estimation methods.

2.2. The concept of GIS-based Decision Support System for air quality assessment

The GIS systems are used for the measurement networks management, for example to analyze and evaluate the location and characteristics of the stations. Their spatial representativeness is an important feature, which allows proper interpretation of measurement results. This is an attribute that is also subject to information reporting to the European Commission within the description of the measurement system functioning in a Member State. Methods for determining boundaries of representativeness area are the subject of various studies [4, 5], including ones presented in this article. An analysis of regional and local dispersion conditions of gas and dust substances is required to assess the representativeness and evaluation of potential public exposure to measured pollutant concentrations. Processing and visualization of spatial information can much help in such kind of tasks.

The processing and analysis of the measurements, modeling results, identification and evaluation of the situation of standards exceedances, including the identification of exceedances areas, constitutes another group of tasks for air quality assessment. The GIS tools are becoming more widely used also in this field. Measurement and modeling can be supported with objective estimation methods. So far, they have been based often on expert assessments e.g. with the supposed analogy between different areas or time periods. Increasingly, these methods use a computer support, primarily based on the GIS, e.g. the analysis of land use or correlation between spatial distribution and activity of emission sources and levels of measured concentrations. Various types of models, e.g. stochastic regression model or multi-source Gaussian dispersion model, as well as, the geostatistical interpolation methods are used to evaluate the exposure to pollution. An important element of air quality management is analysis of the trends of the past and forecasted changes. This is often done in conjunction with the assessment of changes in terms of spatial use and projection of possible implementation of corrective actions. This can be a support for planning, designing and evaluation of strategies and actions to control emissions and air quality management (investments or organizational activities - for example: reduction of car traffic in a given area, changes in traffic infrastructure or domestic heating systems in the analyzed area). Monitoring of the implementation and effectiveness of the applied measures is a very important issue in the frame of this management process [6, 7].

Implementation of the listed tasks can be performed using standard GIS applications and also through the use of own, dedicated tools and solutions. An example of the latter approach is a Decision Support System for air quality assessments, tentatively called AirQualGIS, designed and built in the Air Quality Monitoring Department in the Institute of Environmental Protection - National Research Institute. Its general scheme is presented in Fig. 2. It consists of a group of internal data processing modules, combined with the internal database of descriptive and spatial data, as well as, a dedicated module used for information presentation and user interaction, based on access via a web browser. The data obtained from external systems are processed by the internal interface, which implements also functions of export of data obtained in the system. Currently the system is used, inter alia, for the development and testing of methods, which are described later in this article.

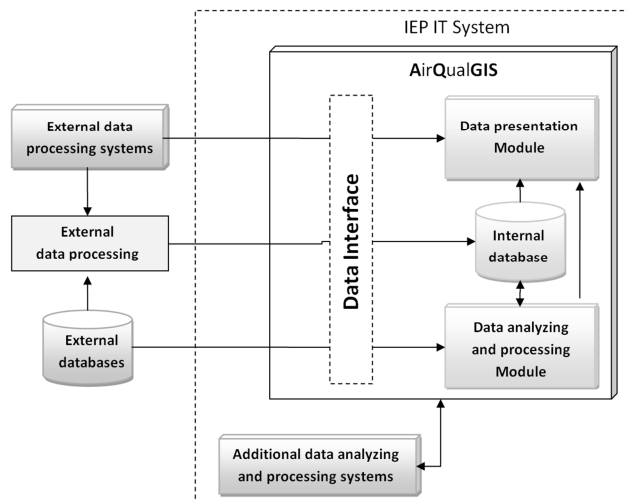


Figure 2. General schema of developed GIS decision support system for air quality assessment

The list of technologies and tools used for the construction of a prototype decision support system, along with the interrelationships diagram, is illustrated in Fig. 3.

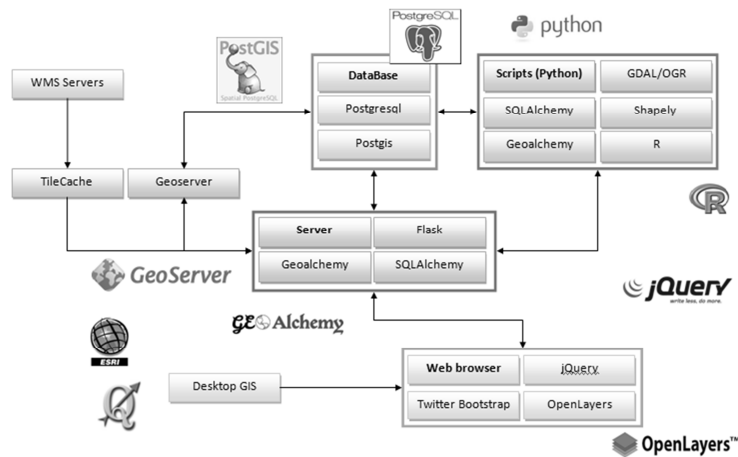


Figure 3. Technologies and tools used in the decision support system

3. Practical examples of the use of spatial information processing tools

Two analytical methods which employ the use of spatial data processing and which can be practically applied in the processes of air quality assessment are described below: Land Use Regression (LUR) method and the so-called Beta parameter method. The authors investigated the possibility of their adaptations and applications in Polish conditions, e.g. for determining the stations' spatial representativeness or ranges of exceedances of the limit levels. These methods were used within the development of previously described decision support system. As mentioned, representativeness of monitoring station is an important element of proper interpretation and analysis of results. The premise, which was adopted in the analysis and modification of the foregoing methods, it was easy availability of the required input data, so that it would be possible to apply them for different regions and periods. Another condition is the speed of data processing and average requirements of hardware resources for example for real-time analysis and visualization. Both these features distinguish these methods from the modeling of chemical pollutants transformation and transport, that may indeed produce more reliable results, but they are in great demand in relation to data and hardware performance, and require highly qualified personnel.

3.1. Land Use Regression method

The Land Use Regression method (LUR) has been more and more widely used in recent years and its popularization is results from the development of the GIS software, often equipped with tools for application of geographically weighted

regression methods. This kind of methods can be used in e.g. real estate market analysis, the studies of the health risks and exposure and environmental analysis related to the soil, water or air pollution [8]. The term "regression" is most commonly used in relation to the method for the prediction of unknown values of one of the variables on the basis of the relationship between knowledge of other variables and their values [9]. A variable whose value is sought is called dependent variable. The relationship between the explanatory variable (or variables) and dependent variable is used to forecast the value of the latter. In case of more complex dependencies, the regression equation containing only one explanatory variable proves not sufficient. In that case, the multiple regression, allowing for the effect of a larger number of variables can be used. Multiple regression equation can be written as (1).

$$y_i = a_0 + a_1x_{i1} + \dots + a_kx_{ik} + \varepsilon_i \quad (1)$$

The parameters a_0, a_1, \dots, a_k are unknown and must be estimated on the basis of a random sample, using e.g. the least squares method. Parameter ε_i represents random components that play the role of random error. The use of multiple linear regression for analysis of air quality is justified by a significant number of explanatory variables that can be used in the description of the spatial variability of concentrations. These include spatial data describing the analyzed area. Potential variables are presented in Table 2.

Table 2. The potential explanatory variables, which can be used in LUR modeling

Source of the variables	Description	Spatial range
Land use	Sum of the areas of particular classes of land use in the vicinity of the analyzed points.	Circle with a given radius of the analyzed points.
Road network	The sum of the lengths of road types (divided by the volume of traffic or road class) in the neighborhood of the point, the distance from the road.	Circle with the radius of the analyzed points, the distance from the object, etc.
Traffic information	The number of vehicles per day on roads in the vicinity of the analyzed points.	Circle with a given radius around the analyzed points.
Population density	The average population density in the area surrounding the analyzed points.	Circle with a given radius around the analyzed points.
Number of households	The density of households in the vicinity of the analyzed point.	Circle with a given radius around the analyzed points.
Emission Cadastre	Point, surface and linear emission. The sum of emissions in a given area or emission weighted with a distance of source from the point.	The sum of the emissions in a circle with a given radius or account of distance from the point.
Location	Geographical coordinates and altitude	-

The dependent variables in the construction of the model can be measured values on the basis of which a model is constructed. These data can be derived from fixed pollution concentrations measurement stations or be collected on passive measurement stations located at selected points within the measurement campaign aimed at developing LUR model. Depending on the scale of the analyzed area such data can be derived from the city, region, country etc. At a later stage of the analysis the dependent variables store the values calculated using the constructed model.

The Corine Land Cover data, road network with traffic information and concentrations of air pollutants included in the AirBase (air quality database managed by European Environment Agency) were used to testing of the method and its implementation in the mentioned earlier Decision Support System. The calculations were performed for computational grids designated within the Mazovian Voivodeship using pre-adopted three grids with different scales and ranges. Fig. 4 shows an example of the average annual concentration distribution of PM10 in the Warsaw and the surrounding area, obtained by modeling based on the LUR method.

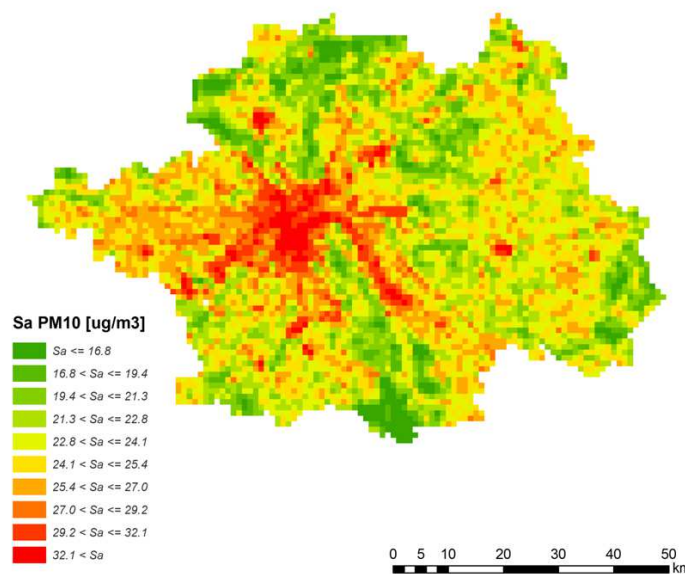


Figure 4. Annual average of PM10 in Warsaw and the surrounding area

3.2. Beta parameter method

So called Beta parameter method can be potentially used for the objective assessment and analysis of spatial representativeness of air quality measurement stations. Similarly, as in case of LUR, it is based on the use of publicly available data

and information, such as land use map: Corine Land Cover and much more detailed Urban Atlas. It is based on the assumption that there is a relationship between the annual average values of pollution concentrations, measured at a given position, and calculated parameter characterizing the cover and land use in the neighborhood of the measurement point. Its foundations were developed as part of the work presented in [4] and [10]. This method involves determination of the parameter β , characterizing the impact of land use on concentration of a selected pollutant in analyzed area. This indicator is calculated using the formula (2).

$$\beta = \log \left[1 + \frac{\sum_i a_i \times n_{RCLi}}{\sum_i n_{RCLi}} \right] \quad (2)$$

where:

i – RCL class index (land use class), occurring in the area,

n_{RCLi} – number of pixels with the class in the area,

a_i – impact factor of the considered area with specified RCL class for air pollution.

The β parameter is the logarithm of the sum of weighted and normalized distributions of RCL classes related to land use. The coefficients a_i are used to determine the weight of the impact of area with a particular RCL class on the pollutant concentration. Procedure for determining the coefficients for individual pollutants consist of two phases. It is assumed that the classes representing areas with a negligible impact on the emissions, i.e. semi-natural forests, green areas, water and wetlands have assigned values about zero. The classes associated with discontinuous urban fabric, which can associated with emissions coming from individual heating systems of buildings and traffic, have the coefficient with value one, for the execution of the subsequent normalization. In further calculations the emissions of air pollutants from various sectors of the economy and of human activity are taken into account, which allows the calculation of the relative emissions from different land classes, and the determination of the initial values of the a_i coefficients. The next step is to optimize the values of the coefficients, taking into account the parameters β , calculated for each measurement station using the long-term (e.g. five-year) average concentration values. The optimization process is based on perfect matching of the coefficients to the designated trend line parameter that minimizes the RMSE (root mean squared error), using algorithms implemented in the solver type tools. Then the value of β parameter can be calculated for all cells of a computational grid covering the analyzed area. Fig. 5 shows an example of the results of the parameter β initial calculation, made with a prototype of decision support system with respect to PM10 pollution. Results obtained with use this method allow, inter alia, on the analysis of the representativeness of measuring stations in air monitoring network. An example for NO₂ measurement site in Piastów is presented in Fig. 6.

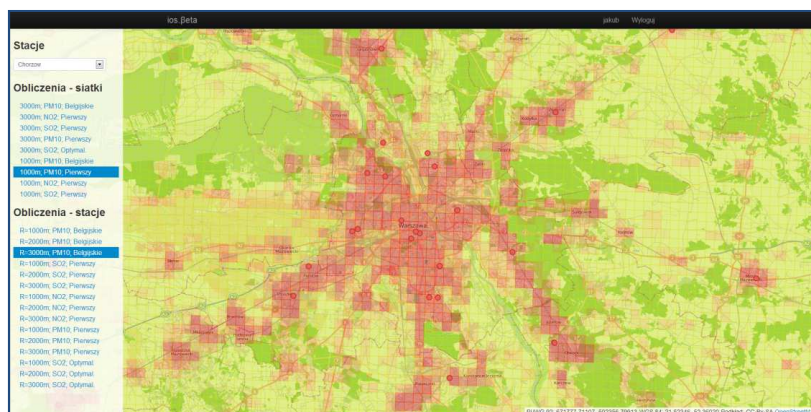


Figure 5. Sample screen of the prototype system - β parameter calculation results for Warsaw and the surrounding area

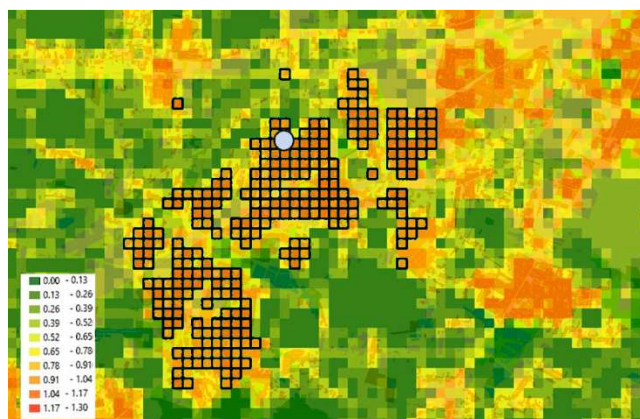


Figure 6. Estimation of spatial representativeness of NO₂ measurement station in Piastów using calculation of β parameter based on Urban Atlas (grid 250 m)

This method, in addition to determining the differences in the impact of land use on air pollution, also allows to obtain the spatial distribution of substance's concentration in the air. For this purpose a geostatistical interpolation of measurements from the stations located in the study area are processed on the basis of the β parameter. Another way to use this method is to increase the resolution of the results obtained by means of mathematical dispersion models.

4. Conclusion

The article presents examples of the practical possibilities of using spatial data processing systems and tools for the management of the air quality monitoring network or analysis and interpretation of its results. The purpose of these methods is, inter alia, standardization and objectifying of determination of the representativeness of stations. The limitations that affect the calculation results must be taken into account, e.g. that meteorological conditions or the advection of pollutants and greater accumulation in certain parts of the studied areas are not included into the analysis. The quality and timeliness of input spatial information is very important as well as and the number of available measurement results. An important feature of these methods is the speed of obtaining the results of calculations and their ability to perform for the various areas of the country. These methods can also be used, for example, in automatically executed generation of pollution distribution maps, based on data from the fixed and mobile monitoring and spatial data - for the purpose of public presentation of current air quality information on geoportals or mobile devices.

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SYSTEMS AND MODELS OF ARTIFICIAL INTELLIGENCE IN THE MANAGEMENT OF MODERN ORGANISATIONS

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Modern organizations commonly use the strategy of a learning organization, and therefore operate with not only material resources, but also information resources. The collected data resources become the basis for generating business and management information. This database is maintained on various platforms using integrated BI (Business Intelligence) systems enabling knowledge to be generated through the data-mining mechanisms embedded in the artificial intelligence models. In this article, the authors focus on AI (Artificial Intelligence) models and systems based on ANN's (Artificial Neural Networks) and fuzzy set theory, which can be useful in solutions dedicated to supporting the complex management of modern organisations, and in particular the support of active functions (forecasting, planning and monitoring activities, as well as risk analysis and system effectiveness).

Keywords: organization, management, operation system, MIS, BI, AI, artificial intelligence, risk, effectiveness, data mining, expert system

1. Introduction

Globalization and widespread computerization and the creation of the information society has increased the demand for advanced systems that improve and support the management processes of organizations. Modern technologies allow for the creation of highly-specialised software, generally known as management information systems (MIS). Systems of this class allow for not only the maintenance of information “islands” organised according to specific domains

into financial or logistic information databases, but also, first and foremost, they force the integration of information resources in such a way as to allow reporting of any cross-section and area of the business. The main objective of MIS is therefore to provide management authorities with actual and cross-sectional feedback of their own activities and those of other's in their field.

MIS solutions as a whole strengthen the positions of organisations and become a specific factor in strengthening the potential of modern enterprises. Systems for computer-aided design and manufacturing (CAD-CAM) as solutions supporting the supervision of industrial processes expose the opportunity and the need to integrate information resources created in different phases of the "life" of the product. This means, above all, the potential of the company is strengthened by utilizing the phenomenon of system synergy that is linked to the coherence and integrity of information resources in authorized places.

Ongoing monitoring of the company, as a whole and as a snapshot of the actual strategic and operational performance against the background of the action plans using historical data resources, is an inherent feature of modern organizations. Today, management information systems are the specific link between all parties involved in the business. In addition, the accumulated information resources can be a source of important strategic information and the basis for knowledge generation. Artificial intelligence systems and models can therefore create added value for companies that are able to extract this knowledge (e.g. Data Mining).

2. The modern organisation as a system of operation

A modern organisation (company, enterprise) should be viewed in terms of both its operation and its resources as a complex operational system integrating human, material, technical-technological, organisational, financial, intellectual and information resources (Fig. 1). This integration mainly involves the integration of implementation and management processes and functions/tasks, including the planning, forecasting, monitoring and evaluation of work processes [9].

The operational strategy of every organisation, as an operational system, should be to emphasise its purpose and the quality of its performance results. The institutional dimension always points to the pursuit of achieving the objectives within a specific configuration, determined by the choice of such methods, in order to achieve these goals within the prescribed time and place according to global quality criteria. The operational environment of the modern organization gives the situational context and determines the type of relationship based on shared knowledge resources and taking into account the criteria of reliability of operations [2, 5].

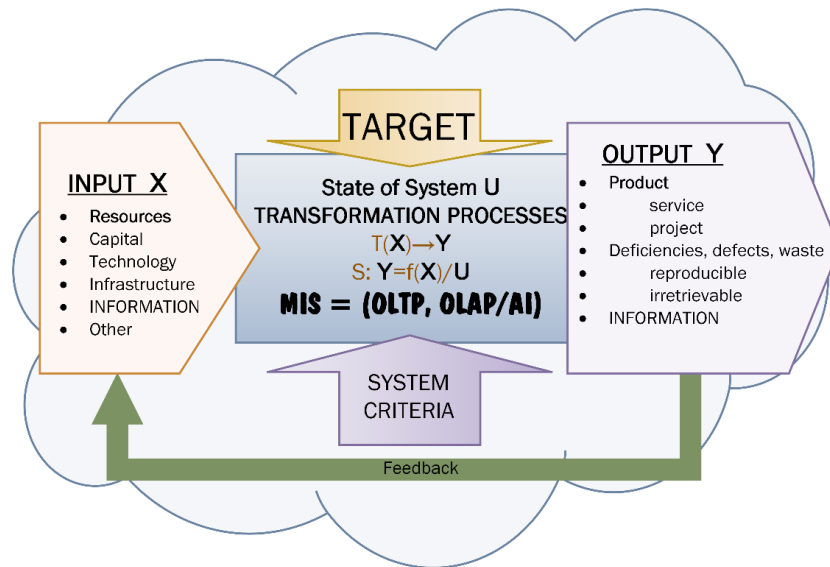


Figure 1. Systemic perception of modern organisations

In modern business organizations, globalization and the opening up to external suppliers and customers should be taken into account. Computer systems therefore allow for the implementation of business projects based on standardized operating procedures. The important prerequisites for the effective operation of modern organizations are a knowledge of the business environment and up-to-date information about the processes, objectives and common benchmarks of business processes. Modern organizations, accordingly, as a set of ordered elements (**E**) and associated with each other by respective relationships (**R**) – have the corresponding structure, strengthened by the effect of synergy [2, 5]:

$$S = \{E, R\} \quad (1)$$

Every organization, as a complex system, is a dynamic structure defined by Cartesian product sets; input (**X**) and output (**Y**) and the states of the system (**U**):

$$S = X \cdot Y \cdot U \quad (2)$$

A modern organization is focused on quality assurance with regard to the efficiency and reliability of the whole and of every part of this system. The role and significance of information flows and decision-making mechanisms in the relationship between the operational (working) and management (control) subsystems is important in this.

Systemic observation of a modern organization imposes unambiguous valuation and assessment of its elements/components. An important part of this are information resources held in integrated systems (MIS), both in operational

(On-Line Transaction Processing – OLTP) and decision-analysis type (On-Line Analytical Processing – OLAP), including Artificial Intelligence systems (AI). The quality of the relationship with the operational environment is determined by the precise and unambiguous definition of inputs and outputs, as well as the flow of information, ensuring effective cooperation within and outside the organization. Being the basis for generating and managing knowledge, information therefore is a specific type of resource for organisations. Evaluation of the level of implementation of the objectives of the organization vector requires the use of objectivised systemic criteria for the types of functionality, usability, reliability (regarded as a function of time, determining the feasibility of the processes under ambient and system conditions, wherein $F(t) = 1 - R(t)$ is a measure of disability / failure of the system or its component), efficiency (defined as the ratio of value and cost of achieving), risk, safety, and systemic quality, which takes into account a variety of systemic attributes, including furthermore reliability and functionality. Consequently, the level of implementation of the objectives of an organization requires a comprehensive evaluation from the perspective of the systemic attribute vector, which requires the use of advanced information technology.

3. The place and role of information systems in the management of organisations

As previously mentioned, information technology binds organisations both internally and externally (Fig. 1). Not all organizations are aware of the economic importance of management support systems. This is often due to limitations in infrastructure and limited trust in external services (e.g. Cloud Computing). In conditions where motivation to change comes from disturbances in the functioning of the organization - the modernization of the information management system usually starts with an immediate search for a solution. In the process of reorganization, external personnel and/or entities possessing relevant, mostly interdisciplinary expertise, are often involved. However, this requires mutual understanding and trust. It is worth noting the fact that most systems can be scaled and adapted to the needs of the organization. This means that an organization can gradually restructure their operating models and implement various subsystems and integrate resources. In response to market demand, highly specialized MIS systems initially evolved into modular solutions, offering ever-greater levels of functionality and often becoming general purpose applications.

The evolution of software dedicated to supporting the management of processes in the organization led to the development of ERP systems (Enterprise Resource Planning). These systems bring many additional features not available in the previously used domain-specific solutions offered by MIS systems. Most ERP solutions are modular framework systems, allowing for flexible adaptation to the

requirements and developed standards functioning in organizations. A characteristic feature of these systems is the so-called single point of data entry into the system and the ability to reuse this information. For example, information about the new contractor can be entered into the system by a mobile trader during the first presentation. These data will be used in subsequent dealings with the customer through CRM module, during shipment in store module, while processing of settlements with the counterparty in financial accounting module, as well as in the processes related to reporting, monitoring and forecasting analytical modules, or controlling.

Particularly noteworthy are the analytical capabilities offered by ERP systems. Although their diversity makes it difficult to uniquely identify a set of features offered by this class of systems, however, due to the similarity of platforms on which they are embedded, you can point to a few areas of typical analytical modules. The main feature is the mode of storage and organization of data. The vast majority of analytical systems use the multidimensional data model (Online Analytical Processing – OLAP) for this purpose. In addition to supporting decision-making processes, the processing of multidimensional data structures, performing trend analysis, financial analysis and general statistical functions, one should point out the ability of these systems to uncover knowledge and associate facts gained using data mining algorithms (Data Mining – DM). Among the wide range of algorithms used in data mining processes, algorithms embedded in artificial intelligence models deserve special acknowledgement.

4. Identification of artificial intelligence systems and models

There are a number of solutions providing advanced analytical models embedded in artificial intelligence systems currently on the market [10]. The most commonly used techniques are artificial neural networks, methods based on fuzzy set theory and evolutionary algorithms.

An example of a solution using artificial neural networks is that, for instance, based on a multilayer neural network, or as a specific case, the perceptron algorithm of the Microsoft Neural Network Algorithm (MNNA). This algorithm has the ability to dynamically create a network of three layers of depth and complexity, depending on the category of the analysed problem. It is worth noting that dual layer implementations, and those therefore devoid of hidden layers, bring about a specific case of the use of the network used in the calculation by logistic regression for dichotomous variables. Consequently, in the process of learning, the algorithm utilizes the mechanism of backward propagation of errors. However, the learning of the network is an operation with a significant degree of complexity and is closely related to the values of the parameters initiating and controlling the operation of the algorithm. The algorithm starts with an evaluation of the tested

data set and the extraction of the training data. At each iteration, a measurement of the result value is taken until a state is achieved where the accuracy of the network no longer increases. In the next stage, decisions are made regarding the complexity of the network itself. For data models dedicated exclusively to forecasting, a single network that represents a complete set of attributes is created mapping the set to be tested. If, however, the data model has mined the attributes used in both the input and the forecasting networks, the algorithm defines a dedicated network for each of the attributes.

In various types of measurements and calculations, values from a set of real numbers are normally used. Contrastingly, people reason and communicate with each other using linguistic terms, in other words, descriptive language. Incongruence in the description of reality can be solved using fuzzy logic. Values in the range $[0,1]$ form the basis of calculations in the theory of fuzzy sets. Processing of real data is done by fuzzy models after a blurring operation, while the transposition of the results into real form is achieved through the reverse operation; so-called, defuzzification [4]. The freedom of the description of the variable is used as the most faithful description of reality. Trying to compare the values of such variables is based on the calculations of the distance of the vectors of these variables, in other words, the extent of similarity of the values.

Another category is evolutionary algorithms. This term refers to optimization algorithms inspired by the biological processes of evolution (crossover, reproduction, mutation, and selection). Mimicking biogenetic processes, algorithms of this class gradually form better and better solutions with each new population [1].

The algorithms embedded in artificial neural network models play an important role in data mining processes. These can be particularly useful in the analysis of complex input data, the source of which can be various ERP system modules or aggregated data in dedicated OLAP systems. Typical applications are predicting volatility of share prices, currency fluctuations, or long-term valuation of other highly liquid financial instruments based on historical data, as well as analysis or prediction of the effectiveness of marketing and advertising campaigns and analysis of production, industrial processes, logistics, transport and storage. You can use virtually any predictive models used to analyse the complex relationship.

The data-mining models presented here result in BI systems and expert systems with a knowledge base as advance information technologies. Implementations available on the market can be obtained after purchasing a license or via access to services in the computing "cloud" [7] (as mentioned earlier, this solution can be especially dedicated to the SME sector, which has limited investment in computer equipment and especially more expensive technologies).

5. Models of management of modern organisations using AI

One of the factors determining the success of modern organizations is the management implemented towards the creation of such a structure in the organization's system of operation that ensures its ability to adapt to a dynamically changing environment. The implementation of such a management model requires the use of Integrated Information Systems Management (MIS) performing forecasting, planning and monitoring functions. The management of modern organisations takes place under conditions of high uncertainty. Consequently, actions undertaken are conditional upon the diligent pursuit of alleviating the influence of those conditions.

Contemporary models of management of an organization are focused on the active use of MIS and on the generation of reliable information. They represent a way of linking support systems for the management of processes in the organization with statistical, prognostic and analytical systems. In view of the very high complexity of the processes supported by MIS, these systems are based on artificial intelligence algorithms. Process management strategy requires the use of information and decision-making systems, which adds an additional determinant in the discovery of knowledge about the future. The implementation the active functions of management is made possible by the intelligent use of information gained by the system; both from specific areas of activity of the organization and from outside it (the operational environment of the organization). MIS are, today, among the most advanced, innovative and growing technologies available on the market [8].

6. Risk and the effectiveness of information processes using AI

The level of computerisation and subordination to information technology of organisations remains in close correlation to the effectiveness of the Integrated Management Information System (MIS). This results directly from the relationship of the obtained results to the incurred investment, and the effectiveness can be seen as the efficacy of realisation of relevant tasks towards a set purpose or the ability to select an appropriate purpose. The effectiveness, therefore, of management implemented using dedicated MIS is directly proportional on the efficacy of these systems. Maximizing effectiveness [6], however, requires the stabilization of the operational environment of the organization, which is in contradiction with the market rules created by reality. By analysing the relationship between the system parameters, it can easily be demonstrated that risk management plays a key role in the process of mitigating the effects of destabilization. The following (in its own way recursive) sequence of cause and effect can thus be defined: management efficacy is maximized by minimizing the effort required to effectively handle risk,

this in turn increases the likelihood of success, minimizing the possibility of an undesirable situation. Maximizing the potential associated with the value of information services enables the management of risk to achieve additional benefits. Taking into account the most likely directions of the development of support systems for the management of organizations, which are primarily expert, multi-agent systems in as well as hybrid systems with built-in artificial intelligence, it is to be expected that there will be effective mechanisms for the optimization of business information processes.

Expert systems are used in many areas of operation of an organization (Table 1) and enable efficient support of complex information and decision-making processes in different categories.

Table 1. Types of expert system

CATEGORY	EXAMPLES OF TASKS CARRIED OUT IN SELECTED AREAS
Interpretation	Speech, image and data structure recognition
Prediction	Prognosis
Diagnosis	Medicine, electronics, mechanics
Assembly	Computer system configuration
Action planning	Movements of a robot
Monitoring	Nuclear power plants, medicine, traffic
Controlling	Management of the behaviour of a system
Correction	Correction of the proceedings in cases of malfunction
Repairs	Schedule or procedure for implementing steps for repair
Instruction	Systems of professional development of students

Source: Mulawka J. J.: Systemy ekspertowe, WNT, Warszawa, 1996

There are also so-called expert system frameworks available on the market, which are domain independent and can be used in any area (from banking and finance, starting and ending on technical applications). Modern expert systems are typically hybrid architecture systems. In other words, they combine various methods of problem solving and knowledge representation. The knowledge stored in the form of sets of facts, rules and metadata may take the form of:

- declarative (classic – rules and facts),
- tripartite – object, attribute, value,
- imperative – in the form of a program or Algorithm,
- textual,
- distributed in a neural network,
- thematically distributed to a number of sources of knowledge.

Sets of rules processed by expert systems often rely on assumptions of the theory of fuzzy sets, as in the case of inference built on the method of fuzzy similarity of method based on the rules (i.e. the dominant characteristics), e.g.:

If the distance for property 1 is „different”
then the distance of objects x, y are „different”.

The properties of expert systems mean that their usefulness in identifying risk in the organization is dependent entirely upon the availability of an appropriate knowledge base. Furthermore, it should be noted that the essence of these systems is to provide detailed knowledge on the basis of general, often imprecise, environmental parameters of the tested problem. Still, the decisive feature of their particular importance is the ability to explain knowledge and the way in which conclusions emerge.

Another innovative path in the development of integrated management information systems is set out by multi-agent systems. An agent, in this case, is a specialized piece of software or algorithm bearing signs of intelligence. To some extent, these algorithms can perform tasks mimicking human behaviour. They often have the ability to learn, adapt to changing conditions and make complex decisions. The diversity of applications and methods of simulating intelligence significantly differentiates the various implementations. A multi-option, visual model of an agent is shown in figure 2.

Multi-agent systems offer the unique functionality of real-time monitoring of basic (defined) parameters of the organization (they can be financial indicators – like KPI's, parameters of the production line, or equipment, location of resources, or virtually any other data of any degree of dispersion. Systems of this class support risk monitoring process in the organization and allow the early identification and promoting active response to any alarming signals). A characteristic feature of multi-agent systems that distinguishes them from other solutions designed for monitoring is the ability to predict events, the occurrence of which, under normal conditions, is manifested in the attainment of established threshold values for monitored parameters.

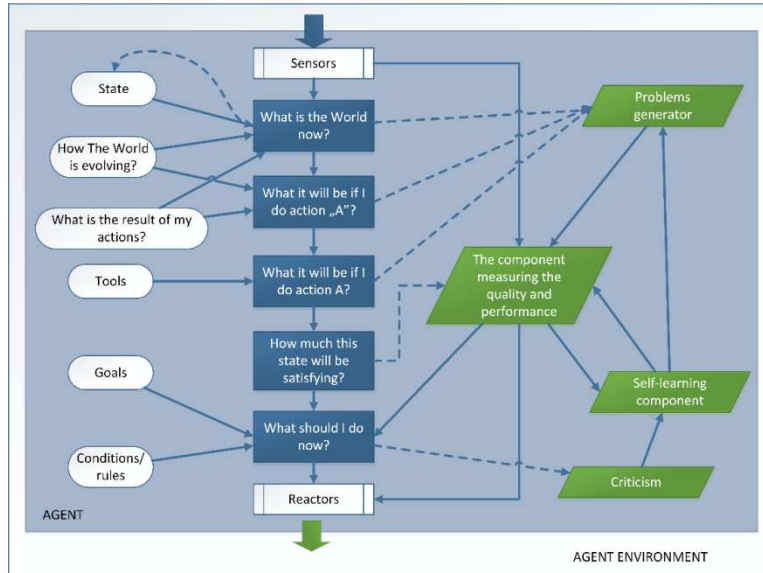


Figure 2. Extended multi-option model of agent
Source: own preparation based on [3]

Of particular importance for the development of MIS are hybrid implementations of various techniques of artificial intelligence. Hybridity, in this context, means combining different algorithms to extract and emphasize the unique characteristics of the individual methods and synergies. A commonly used example of such a hybrid system is the Co-Active Neuro-Fuzzy Inference System (CANFIS). CANFIS networks combine the features of high precision in artificial neural networks with the flexibility and naturalness of fuzzy logic. They are used in solving highly complex nonlinear estimation, classification, association, recognition, optimization and control. These methods are used in the risk analysis of information processes. The decisive factor in determining their use is the synergy effect manifested in the ability to manipulate linguistic data (the values of system parameters) in classification, prediction and estimation tasks.

7. Summary

Structure, models and concepts of operation of process-oriented modern organizations are submerged in an environment of solutions and information systems. The ability and the possibility of evaluating processes and their performance results is conditional upon access to appropriate resources. The model of the operation and management of processes in modern organizations should include formal methods and advanced information and communication

technologies. The solutions that provide access to current and reliable information can be found in the development strategy of each organization. Hence the emphasis these days on the need to implement MIS class OLTP and BI (OLAP with DM functions based on artificial intelligence models). Artificial Intelligence plays a special role in the systems used to obtain knowledge from data sets [11, 12, 13]. Modern methods of obtaining and storing data clearly develop in the direction to be known as Big Data. It not means in this case extremely huge volumes of data sets (although this fact usually goes hand in hand with the term Big Data), but about the structure of the data. The term Big Data is used to describe unstructured and non-relational data sets, whose analysis and processing to extract the knowledge (Data Mining) must be based on finite period of time (sometimes in real time). Such rigorously formulated conditions practically exclude use for analytical purposes classic statistical methods. In contrast, tasks such initial classification, search patterns, syntactic and semantic analysis, etc., are supported by various techniques of artificial intelligence.

Increasing the efficiency and flexibility of modern organizations may ensue from increasing the independence of process implementers and their dynamic selection according to criteria of availability and administrative competence (these process becomes the object of the organization with the ability to manifest intra-organizational relationships and the outcomes of the processes; it should also be borne in mind that the quality of the process rests with the executors appointed in the process of structural integration, information and personnel). MIS enhance the potential of the organization, but require the collection of relevant information resources and the extraction of useful knowledge about the future (forecasting, discovery trends, clusters, etc.).

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QUALITY FUNCTION DEPLOYMENT FOR DESIGNING COLLABORATIVE WORKING ENVIRONMENTS

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This paper presents quality-oriented approach to designing Collaborative Working Environments (CWE) - socio-technical systems, in which technology is mediating human interactions for purposes of group cooperation. Both technical and social aspects of virtual collaboration are characterized by high level of complexity, therefore process of designing CWE's should benefit from approach supporting such complexity. It will be shown, how the Quality Function Deployment method, used for managing the development of complex products, can be utilized into the process of designing such systems.

Keywords: Collaborative Working Environment, E-collaboration, Quality Function Deployment

1. Introduction

Spatially distributed groups use technology for mediating collaborative activities of its members over time and distance. Usage of such technology has influence not only on the quality of the task performance, but also on social and individual aspect of group membership. These social and individual needs impact effectiveness of cooperative processes. Different aspects of the communication in virtual environments are still being researched and designing effective computer-supported environment supporting these issues still remains a challenge [10].

Meeting the challenge of the designing process requires taking into consideration different aspects of collaborative interactions: from both social and technolog-

ical perspectives. However, many aspects of computer-mediated interactions are not sufficiently explained yet, therefore many publications underline issues of lower effectiveness of virtual groups than in face-to-face groups related e.g. to: coordination problems [4], social aspects [11, 13] or information overload [7].

The process of designing Collaborative Working Environments (socio-technical systems, in which technology is mediating human interactions for purposes of group cooperation) is very complex. This paper presents a quality-oriented approach of designing such environments with the usage of the Quality Function Deployment method in order to provide a tool for managing such complex process. Expert's evaluation of the QFD matrix will provide basis for creating a prototype of such environment.

2. Challenges for the designing process

Virtual communication is perceived as a real communication [18], and virtual groups follow the pattern of group development similar to face-to-face groups [13]. As for real groups, also virtual collaborative processes are influenced by the three following areas: task orientation, individual support and group maintenance [1, 3, 12]. These three aspects are necessary for a group to effectively perform common activities.

Problems with supporting these aspects of collaboration have been discussed in literature e.g. in terms of anonymity and disembodiment in communication process [18], group cohesion [8, 11] or performing a task [9]. Some of them result directly from the design approach. Design approach implemented for developing software for supporting group collaboration (groupware) has been described as a "top down" approach - because of its mostly organizational orientation and clear and defined processes between team members. Groupware is described as supporting a defined socio-technical system [16].

The opposite of this approach is a "bottom up" approach of social software (e.g. for social networks), where the decision on how to use it is made by user. However, problems may emerge, because it gives the user multiple possibilities of interaction, but no specific patterns of their usage.

In the meanwhile there can be tendencies seen of incorporating social software into an organizational environment as an extension of groupware functionality and both approaches combine.

Still, multiplicity of existing modules for supporting interactions, their complexity and possible combinations present a challenge in the process of designing Collaborative Working Environments. Therefore, this article presents an approach based on the methodology of designing complex products - Quality Function De-

ployment, which seems to be suitable for the introduced problem and can contribute to the first phases of the software engineering process.

3. Quality Function Deployment method

The process of designing Collaborative Working Environments is complex, which results from the multiple areas that need to be taken into consideration. Collaborative environments are socio-technical systems consisting of multiple interrelated variables and the complexity of correlations results in a need for an evaluation tool that can model defined relations. Tools satisfying such evaluation are provided by Quality Function Deployment method (QFD) and are a subject of this article. Although developed already in the late 1960s (Japan) it is still successfully implemented as a design tool in many organizations and industries [2], also in the area of software design [14].

The focus of Quality Function Deployment with its concept of House of Quality is on creating products basing on customers' needs: their desires and tastes. House of Quality is a graphical extension on top of the QFD approach, providing instruments for interfunctional planning and communications [5]. The basic concept of the House of Quality is presented on Figure 1.

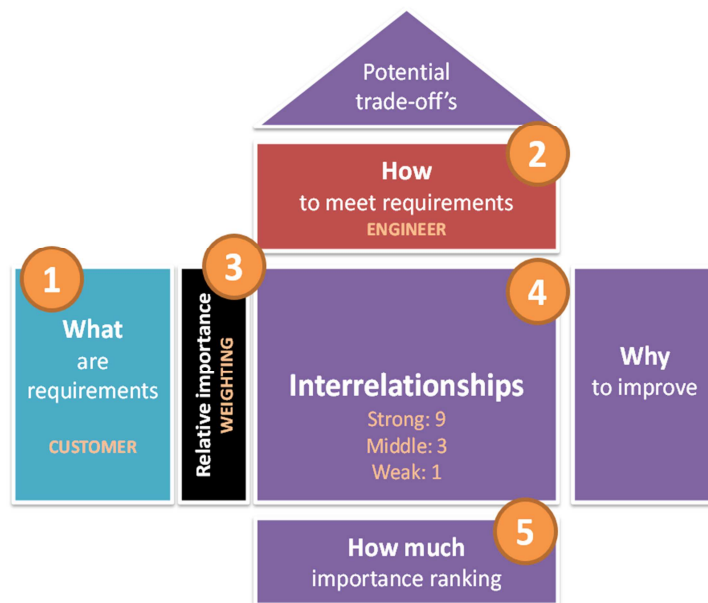


Figure 1. Schematic diagram for House of Quality

The main idea of the Quality Function Deployment method related to the subject of this article consists of the following main steps [5]:

1. Identification of customer attributes (so called *whats*).
2. Identification of the ways of achieving the whats – engineering characteristics (so called *hows*).
3. Identification of the relative importance of customer attributes.
4. Definition of relationships between *whats* and *hows*.
5. Identification of customer evaluation of competitive products.

Customer requirements (1) are identified firstly and often grouped into categories to make the reading of the matrix easy.

The *how to meet requirements* table (2) contains engineering characteristics (EC's) impacting potentially one or more of the customer attributes. If EC does not affect any customer requirement it may be redundant or a requirement is missing. This may potentially lead to expanding the list of customer attributes. A list of attributes may also contain an indication of how engineers influence customer-perceived qualities – e.g. if the direction of influence is positive or negative.

Customer requirements are mostly not equally important - table of relative importance contains weights (3).

The influence of EC's on customer requirements is indicated after defining both *whats* and *hows*. A relationship table (4) defines the strength of the relationships and contains numbers or symbols. The strength of the relationships is mostly defined as weak (weight: 1), middle (weight:3) and strong (weight: 9). Such weighting is not obligatory, depending on agreement other weights can be used as well [6, 17].

If any characteristics that have to be improved simultaneously need to be specified, it can be indicated in the “roof” part of the house. Engineers define a type of relation and take a decision about trade-offs affecting customer benefits.

The *how much* table (5) contains objective measures that enable benchmarking of competitive products. It also informs about importance ranking for engineering characteristics.

Table *why to improve* allows comparing customer's evaluations of competitive products according to the defined customers' attributes.

4. QFD method for designing Collaborative Working Environment

The customer (1) and engineer (2) tables of the QFD are defined as:

1. **Collaboration needs** that constitute *customer* requirements in the QFD approach. Processes of collaborative groups have been widely described in literature and provided basis for defining collaboration needs part of the model.
2. **Collaboration support** that defines *engineering* characteristics part of QFD. For the purpose of design, there have been available features of collaborative software defined in order to link them with collaboration needs in the interrelationships matrix.

The set of customer requirements results from the literature analysis and has been organized into three categories: individual needs (learning, belonging), task needs (production, discussion, problem solving) and group maintenance needs (motivation, trust, cohesion, identification) [1, 3, 12].

The list of Engineering Characteristics has been identified and consists of 34 general *features* of collaborative software (e.g. discussion board, social rating, video-conference, notifications, etc.) [15].

Designing process has been divided into the following phases:

- Initial analysis – required for identification of potential interrelationships between customer requirements and EC's part of the QFD. This phase allowed for the identification of potential requirements or engineering characteristics for which no interrelationships have been defined.
- Expert evaluation of the QFD – required for defining the strength of the interrelationships and the importance ranking of the features for satisfying customer needs.

In the initial analysis phase there has been defined possible existence of the interrelationship between every requirement and EC. The basis for this phase was literature research. Existence of the interrelationship has been marked in the table by an 'x' sign. The strength of the relationship has not been defined due to the fact, that available literature resources didn't allow to draw conclusions about relative importance of analyzed features. The result of this phase was a matrix, where all customer requirements and EC's were matched (Figure 2).

This initial matrix provided first insight into the potential importance of the analyzed features of collaborative software.

	private message/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference
Individual Needs								
Learning	x	x	x	x	x	x	x	x
Belonging	x		x	x	x	x		
Task Needs								
Production	x	x	x	x	x			
Discussion (asynchr.)	x		x	x		x		
Discussion (synchr.)						x	x	x
Problem solving	x		x			x		
Group Maintenance Needs								
Motivation			x					
Trust	x		x					x
Cohesion			x			x	x	x
Identification		x	x	x	x			

Figure 2. Excerpt from the initial analysis of relationships between needs and functionalities. *Source:* [15]

The second phase of the process was expert evaluation of the interrelationships in QFD. The interviewed experts were members of the leading German research institutes dealing with aspects of technology for supporting collaborative group work with experience in using, designing and developing collaborative software as well as in social and psychological factors of group collaboration from the Fraunhofer-Institut für Angewandte Informationstechnik FIT, Rheinisch-Westfälische Technische Hochschule Aachen, University of Siegen and University of Bonn.

The aim of this phase was to confirm correctness of the initial analysis and to collect information about the strength of the interrelationships defined earlier.

The strength of the relationship was defined using the following scale:

- * – weak relationship (weight: 1)
- ** – middle relationship (weight: 3)
- *** – strong relationship (weight: 9)

It has been found, that all expert's evaluations have been similar to each other with minor differences in assessment, which assured consistency of the results. The answers have been averaged and therefore the table can be considered as a representative experts' opinion on the topic of the requirements-features fit.

	private messages/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference
Individual Needs								
Learning	**	*	**	***	**	**	**	**
Belonging	*	*	*	*	*	*		
Task Needs								
Production	*	**	**	**	**	*	*	*
Discussion (asynchr.)	***		***	**	*	*		
Discussion (synchr.)						**	**	***
Problem solving	*		*	*	*	**	*	*
Group Maintenance Needs								
Motivation	*		**	*	*	*	*	
Trust	*		**	*	*	*	*	**
Cohesion		*	**	*	*	*	*	**
Identification		**	**	**	**	*	*	*

Figure 3. Excerpt from the expert evaluation: QFD relationships table and importance ranking. *Source:* [15]

It has been also found that answers are consistent with the table resulting from the initial analysis and therefore it provides ground for validating initial analysis of the collaborative features.

This evaluation allowed for drawing the following conclusions:

- Collaborative group needs cannot be met by a single tool or a pair of features, but require a combination of tools to effectively fulfill all the aspects of group needs.
- There are collaborative features that meet a broad range of group needs (e.g. discussion board) as well as features with very limited potential support for collaborative needs (e.g. web feed).
- Collaborative features found most valuable originate both from social software and groupware systems.
- Social software features were found valuable not only for meeting social needs, but are also perceived as able to support task needs.
- The social networking functionality is not only perceived as a tool for connecting with friends, but also as a tool helpful in generating trust as well as a tool valuable for learning needs: e.g. finding experts or professionals.

The set of features found most valuable by experts contains: discussion board, social rating, wiki, video-conference, private message/email, calendar and chat.

This first analysis provided background for creating a first-stage prototype – a web-based platform that will be a subject for testing the appropriateness of the QFD process.

6. Conclusions

The Quality Function Deployment is an approach for creating products basing on customers' needs. Development of IT systems can benefit from the implementation of the QFD approach, especially in the process of designing complex socio-technical systems. This article presented possible implementation of the QFD method in the process of designing Collaborative Working Environments. The Quality Function Deployment method can be implemented as an extension of the traditional software engineering approach as a decision support tool, however usage of the QFD can be also extended on further phases of the software engineering process [14].

This article presented the process of utilizing QFD method, starting with gathering customer requirements – needs of collaborative groups, defining engineering characteristics – features of collaborative software, then defining interrelations and putting them into QFD matrix. As a result there have been identified key features required to be implemented in Collaborative Working Environment in order to satisfy customer requirements. These features have been identified according to expert's evaluation of the QFD matrix and will be subject for implementation of the prototype of a collaborative system.

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ON SOME RECENT PROBLEMS IN COMPUTER EDUCATION ON ENGINEERING STUDIES

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Education concerning computer tools for the future engineers is present at the universities for over 40 years and since every student of engineering faculties (not only computer engineering) obtains knowledge of computer applications and data processing tools. We are often asked why do we teach IT if the computer is commonly used and every student is well acknowledged with its applications. New problem arises as the students use computers, but do not understand its meaning in their future work. There is a gap between everyday thinking of computer application and real needs for the engineer. The aim of the presented analysis is to discuss how to fill this gap and prepare syllabus to gain students interest and present them with understanding of the tools they are about to use in their work.

Keywords: IT curriculum, computing tools for engineers

1. Introduction

Educating engineering students in the field of usage of the computer tools is present at Warsaw University of Technology for over 40 years. It is obvious that every student of all engineering faculties (not only computer engineering student) should obtain the knowledge of computer applications and data processing tools.

In the early seventieth information technology as a subject was introduced in most of the faculties of our University. It was something modern, new to the students and nobody neglected that it is needed in the future work. It was mainly binary mathematics and programming then.

Today we are often asked why we should teach IT when a computer is commonly used and every student should be acknowledged with its applications. However we come over a completely new problem – the students use computers, but do not understand its real meaning in their future work. There is a gap between everyday thinking of computer application and real need for the engineer. There is a problem of digital literacy and “telepresence” as opposed to presence in the real world [1].

Regular contact with short visual information since early childhood might in a long term influence the perception ability of peoples’ brain [2]. New “digital generation” is at our doorstep.

2. Filling the gap

The aim of the presented analysis is to discuss how to fill this gap. How to prepare syllabus to gain students interest and present them with understanding of the tools they are about to use in their work. The problem concerns several basic educational topics:

- How to develop an understanding of commonly used numerical methods for solving engineering problems and the ability to appropriately apply numerical methods with the knowledge of some of the limitations of such methods.
- How to manage large portions of data with commonly used tools as spreadsheets and databases.
- How to develop a knowledge of basic programming concepts and the ability to write simple programs to apply them as a tool in applications like CAD and other engineering tools.
- How to select the information obtained via Internet – the choice between the good and the rubbish.

The aims are quite clear, but incorporating them to the syllabus is rather difficult. The syllabus should be aimed at understanding not at practical skills in concrete software. We do not know what software will be available in 3 to 5 years from now when the students will get their degree. So we need to concentrate on broad concepts using specific tools only as an illustration and example.

An approach of the students is rather negative – they assume that they are well educated in computing techniques so they neglect the need of general education. Reality is quite different – they are illiterate even in terms of using such applications as word processor. Their thinking is limited to search engines (like Google) and learning menus of certain applications, rather than on reasoning and general need of the tools.

The problem is also in a very low level of school education. Our experience shows that large percent of the first year students is not aware of real strengths of

modern computer application on one hand, over estimating Internet techniques on the other. The approach that everything is easy and “done by the program”, so there is no need to study it. It is for them like using a hammer and saw, so they do not accept the need of understanding the complexity and theory needed to use the tools properly.

3. Building a curriculum

The consequence is that we are often approached by the students with the following questions:

- Why do we need to learn IT basics?
- Why do we waste time on general information of data encoding, search and validity?
- Do we at all need to learn programming as we will not build the software?
- What is the reason to learn the general information on tools like spreadsheet or math tools (like Matlab)?
- Why we should learn CAD basics instead learning it in practice during construction or design classes?

We include these questioned topics in our curricula. An analysis of the curricula at most of the technological faculties shows similar approach. So the problem is not what to include, but how to present the contents to the students, so that during 30 to 60 hours of classes they get not only the knowledge, but also get convinced that they did not waste their time. We should analyze the attitude of the students as it is presented in [3]. This is something really important in the course of curricula improvement.

3.1. Curriculum – lectures

Generally we should include the content of IT for engineers as a general subject, similar to mathematics and physics, trying to avoid an application oriented approach. This implies the role of a good lecture at the start of the classes. The lecture should consist of three general blocs:

- Information encoding: a very important topic showing that all information available conforms to some general rules. There is an important element of breaking encoding into certain levels to show the consistency of the applied methods.
- Data obtaining, storage and processing: a general approach to data, their validity, ways of storage and processing methods. Some references to data management tools might be useful, but the emphasis should be put on the availability and validity.

- Programming basics: a program as a way to present an algorithm, not as a software development tool. Program and programming should be shown as the last step in the analysis of the problem and one of many tools to make use of an algorithm. Understanding the relation between an engineering problem and a solution is key element.

The lecture will thus help to show the background of information storage and processing, emphasizing the role of IT with some depths in the opposition to plain clicking “solve” button in any application.

The practical part of the curriculum must be oriented on general implementation of the above lecture topics. Generally we may divide the practical classes into similar groups of topics. We need some presentation of data encoding, and a large block of engineering tools enhanced by the elements of engineering software.

3.2. Curriculum – the practical part

Let’s try to look at the types of applications and their role in the curriculum. We may classify the tools into three groups: general data processing, general engineering tools and specialized tools for engineers including different types of computer graphics. We will now look at these groups from the point of view of the curriculum keeping in mind the questions and doubts that our students still have.

Practical classes should be built upon an idea of three steps to the solution – presentation of the problem, choice of a tool (appropriate software) and finding specific functions. The students cannot base on specific software including specific version, memorizing menus, steps and the names of the functions. They have to search for the tool basing of a general idea what he or she is supposed to obtain as a result.

It is preferred to split the practical course into 3 or 4 semesters. The students should be gradually introduced to the tools that are more and more oriented on solving practical engineering problems. We propose the following groups of applications:

- Spreadsheet as a tool of basic data analysis with the emphasis on filtering and aggregation of the data. It is especially useful for the specializations where the large number of data has to be considered. It may be combined with programming basics, pointing out the possibility of programming elements included in such tools like spreadsheet (i.e. Visual Basic for Applications).
- Engineering tools to perform calculations, solve equations and various numerical problems. (i.e. tools like Matlab or MathCAD). It might be combined with statistical tools for engineers, especially where predictions and forecasting of natural events is important.

- CAD applications for engineers, without the emphasis on a specific application. Depending on the needs 2D or 3D tools should be considered. It is often useful to spend some time on general computer graphics topics.
- Depending on the type of the studies it may be useful to introduce data bases, optimization or some other specialized data processing tools. It would be usually incorporated in the curricula of master courses, rather than on the basic engineering studies.

It is very important to show real life examples within each application and as much as possible to tie it with engineering lectures in the semester. This is the way to convince students of the need of IT education throughout the course of their studies.

Without elimination of good lectures in the practical part we should turn towards project-based learning, as presented in [4], where the authors suggest, that recently students are “graduating with good knowledge of fundamental engineering science and computer literacy, but they don’t know how to apply that in practice”. Well, there is the need of both ends, where good convincing lecture has to be followed by the practical approach to the problems.

One cannot neglect the problem of team work as stressed in [5]. However this is the most difficult part in creating of curricula in technological universities in Poland. This problem will be further analyzed by the author.

4. Conclusions

As we can see the new curriculum of IT studies has to show general ideas in the course of the lectures, showing wide view of IT as a basic discipline. On the other hand exercises must be strongly connected with practical examples, as it is often referred to as “project-based”. It is a very good idea to let the students influence introduction of constant changes to the curricula, possibly in an online contact with the teaching staff. At our University the curricula are not flexible enough and it has to be changed. We should move towards flexible course selection systems as presented in [6].

Changing the attitude of the students and presenting them with acceptable curriculum should be our aim in the constant process of the IT curricula development at technological universities.

The real problem in curricula is the position of IT education in relation with the other subjects. Basics and understanding has to be introduced possibly early (first semester), whilst practical part, after some engineering knowledge is being taught (third semester or even later). Combining these two contrary needs is a real challenge for the future.

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ASSESSMENT OF THE IMPLEMENTATION OF THE ELECTRONIC CITY CARD SYSTEM IN BIAŁYSTOK

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The objective of the paper is to assess the implementation of the electronic city card system in the city of Białystok. The city card has been used since July 2011 in Białystok. This is a system which covers fewer functions than a similar system in Wrocław. A comparison of the city card with paper tickets with respect to the functions they cover is favourable for the new solution. A questionnaire study performed in 2014 among passengers resulted in a positive assessment of the new solution of the electronic city card system.

Keywords: electronic city card system, city logistics, IT solution

1. Introduction

Large cities are characterised by fast development in the areas of economy, production, culture and fast development of transportation networks [8]. Effective functioning of cities is possible as a result of managing transportation. Transport which includes the carriage of goods, persons and information by applying appropriate means is a core factor determining economic development of cities [1].

City logistics is applied to resolve problems related to the growing traffic in highly urbanised agglomerations [4]. The idea to apply logistics for those purposes was first applied in the late 1990s resulting in the establishment of a new field of knowledge [15]. City logistics has a macroeconomic dimension and nevertheless it is focused on specific areas functioning in specific micro regions [7]. The essence

of city logistics is provided e.g. in the definition developed by the Council of Logistics Management (CLM). "City logistics is termed as a process of planning, performing and controlling of flows initiated outside and directed towards the city, initiated in the city and directed to the outside, passing through the city and internal in the city, and the accompanying flows of information, aimed at providing for the needs of city agglomerations in the area of management quality, life quality and development" [14]. "City logistics is also defined as a process optimising all activities related to the storage and transport performed by enterprises in the city with due focus on the surrounding of the processes, transport congestion and energy consumption in a market economy" [5]. According to B. Rzeczyński "city logistics provides assumptions to optimise the city system with respect to planning, controlling and supervising all conditions that are subject to traffic, the occurring processes in the economic, ecological, technological and social dimensions" [6]. Another definitions developed by German authors terms city logistics as a "set of actions based on collaboration among forwarders, carriers and other entities in logistics centres as well as those outside centres, aimed at coordinating provisions to the city subject to combining goods flows in order to minimise the number of operations and goods traffic in the city" [2]. City logistics consists in controlling the flows of all resources within the city between sub-systems [3].

Activities covered by city logistics may be carried out by city authorities as well as municipal companies such as public transport, utilities (gas, heat and water suppliers, city sewage treatment plants [16]. City transport and the related passenger flows are a specific area of city logistics [14]. Public transport consists in moving people (less frequently goods) solely within city limits or in the suburbs. Public transport is performed at specified time intervals along designated transportation routes and is generally accessible to inhabitants [18]. The application of modern technologies facilitating the use of public transport is a good solution resulting in acquiring a larger number of passengers for public transport. Those include multifunctional city cards [9].

The Electronic City Card System in Białystok uses microprocessor media that constitute a part of an intelligent system. A plastic card similar to a bank card is used. The required data is stored in the card memory. Cards are issued at designated outlets where they can be personalised and recharged. The name of the city card is often abused and identified with electronic tickets – however, it may have at least one more function than a standard e-ticket. City cards may additionally be used for parking or entry to various cultural and sports facilities [10].

The functions of the Electronic City Card System include: possibility to operate loyalty programs, fast and seamless modifications to the prices, electronic sales of tickets, one method to charge services for several city services, monitoring of service quality, easy method to charge fees for riding without tickets, an

improved image of city services, possibility to generate analyses as required by customers, reduced costs of city services [11].

2. Methods of research

The objective of the paper is to present a modern method of information management in public transport - being the electronic city card system. The city of Białystok was selected for the study where such system was implemented in 2011. The study is based on questionnaires addressed at passengers and interviews with employees of the Municipal Public Transport Enterprises in Białystok. The questionnaires and interviews were held in the first quarter of 2014. The results of the research are presented in several stages. In the first stage, a comparison was made between the city card system applied in Białystok and the one implemented in Wrocław. Subsequently, a comparison was made between the functions of city cards and paper tickets. The questionnaires resulted in an assessment of city cards by passengers.

3. Results

The electronic city card system in Białystok is a comprehensive IT solution covering passenger transport and payments for services provided by public transport operated by the City of Białystok. The system comprises a central system named the System Support Centre (COS), located in the City Office of Białystok and the interoperating site sub-systems that include: vehicle systems on board, electronic cards containing public transport tickets, card sales and personalisation outlets [12]. All those elements made up one integrated IT system supporting the Białystok City Card. The central system is composed of several modules responsible for various functions, e.g.: system administrator tasks, sales and overall customer service, card personalisation, data transmission, data processing and standardisation, analyses and report generation, monitoring of vehicle and data transmission to information boards at stops, analyses of contracts and operators' settlements, support to the system responsible for calculation of passenger flows in public buses.

The implementation of the electronic city card system in Białystok was preceded with a number of preparations. The first element was to implement an electronic system to measure punctuality in 1991. The next stage was to implement a modern passenger counting system in 2001 in 58 buses. Since 15 November 2010 it has been possible to pay with mobile phones for tickets [13]. The construction of an integrated electronic city card system began late in 2010 and the system was implemented in July 2011. On 14 July 2011 a full ticket offer was made available

on the basis of the electronic city card system. First, the new system was being tested with the old system of season paper tickets operating in parallel.

Apart from Białystok, also the city of Wrocław decided to implement electronic city cards. In order to identify the sophistication level and the features of the systems, it is necessary to compare the systems and to present the functions of city cards in Białystok and in Wrocław. The Wrocław city card has been functioning since May 2010 and it is based on UBRANCARD.

The major differences between systems used in Białystok and in Wrocław include the scope and the offered functions. The Wrocław card cover public tram and bus transport while the Białystok card covers solely buses. The operations of the cards, their functions, differences and similarities and plans for the future are presented in table 1.

Table 1. Functions of the city cards in Białystok and in Wrocław

Name of function	Białystok City Card	Wrocław City Card
Electronic public transport ticket with a possibility of counting passengers	When a season ticket is purchased, public buses can be used. On entry, the tickets shall be approached to the activation device.	When a season ticket is purchased, public buses and trams can be used. On entry, the tickets shall be approached to the activation device.
Electronic city purse	The function enabling transfer of a specific amount, enables the purchase of single-ride tickets.	No function – only electronic city single-ride tickets can be purchased.
Fees for parking	The function is planned when the functions of the city card are extended.	The function operates in combination with the city card and the park meter system.
Tickets to Aquapark and the Zoo	No function	It is possible to code the ticket to the card subject to prior personalisation.
Operation in libraries	No function	Possibility to use in selected Public City Libraries.
Entry tickets to mass events.	Entry to the city stadium.	No function
Payments with the city card.	The function is planned by PKO	Citibank City Debit Card, Visa prepaid Visa cards, payWave BZWBK
Tickets for passenger trains	No function	Possibility to ride passenger trains without additional fees in Wrocław.

Source: Author's study on the basis of information published on web sites

The Wrocław city card integrates many more sphere of life of the inhabitants that the Białystok city card. The URBANCARD may be used as a reference for future development for the Białystok city card.

Before implementing the city card, a system functioned in Białystok that was based on paper season tickets. Such tickets contained the holder's photo, their exact details and information on any reductions holders may have. The person verifying ticket validity also had to verify a separate document entitling to reductions. Such

season paper tickets were extended by the purchase of a special stamp at a customer service outlet with a validity date to use public transport in the specified zones and times. The ticket was comfortable to use since its usage within its validity was limited solely to displaying it controllers; no validation on buses was required. However, the system was open to abuse, did not provide sufficient information required to enhance public transport and adversely affected the image of public transport in Białystok. In order to assess the validity of the decision to implement the new system it is necessary to compare the season paper ticket system with the electronic city card system. Table 2 contains a specification of functions and operations performed by both systems. The first column presents a specific function or operation while the other two columns provide information on the relationship of each operation with the relevant system. In each line the word “yes” means that the specific function or operation is related to the relevant system while the word “no” means that it does not exist.

More negative features were displayed by the season paper ticket system: as many as 19 out of 28 of all the operations and functions in the table. The electronic city card system had as few as 6 negative factors out of the 28 functions. Thus, the new system had more positive features than the previous one.

Table 2. Functions of the electronic city card system and the periodic paper ticket system

Function/operation	City card	Paper tickets
Alignment of customers' data with the sold services, possibility to determine the overall demand for a specific service	yes	yes
Recharging the season ticket over the Internet	yes	no
Planning of future demand for the services for a specific public line in terms of time and location	yes	no
Identification of the number of passengers by age groups	yes	no
Modification of transport tariffs for age groups	yes	no
Acquisition of information on the places of ticket purchase at a specific time and identification of service outlets with excessive load	yes	yes
Counting of passengers in each bus	yes	no
Analysis of bus line load during the day	yes	no
Automatic identification of delays at stops	yes	no
Identification of the actual bus location	yes	no
Possibility to acquire various information on passengers	yes	no
Automatic generation of reports and analyses	yes	no
Support to services related to settlement of services between the various involved entities	yes	no
Ongoing supervision over the correct performance of services	yes	no
Automatic information on any system failure	yes	no
Possibility to account for all applicable reductions	yes	yes
Need to hold a document confirming the right to reductions	no	yes
Possibility to purchase single-ride tickets in vending machines on the bus for the passenger and accompanying persons	yes	no

Table 2. Continued

Function/operation	City card	Paper tickets
Possibility to purchase tickets from the driver	yes	yes
Possibility to recharge the ticket only for the specific month irrespective of the recharging day	yes	yes
Performance of more than one operation by the electronic ticket	yes	no
Automatic analysis of punctuality	yes	no
Need to place the ticket on the validation device	yes	no
Possibility to forge tickets	no	yes
Possibility to determine the passengers' route by the operator	yes	no
System failure rate	yes	no
Modification to the prices of services without costs	yes	no
Insufficient number of appropriate validation devices	yes	no

In order to obtain an opinion on the implementation of the city card system in Białystok it was necessary to carry out a questionnaire among 100 random users of public transport. The questionnaire contained 20 questions. The questionnaire was completed by three persons aged up to 18, 62 persons aged 19-29, 21 persons aged 30-40, 7 persons aged 41-51 and 7 persons above 51 years of age. Most of the persons completing the questionnaire identified commuting to school or work as the basic reason for travel (totally 65 persons) and the use public transport every day (57 respondents). Out of the 20 questions, six referred to the city card. The responses to question one showed that a majority - as many as 56 persons – assessed the reliability of the system as good while nine persons stated that the reliability was very good (Fig. 1) Poorly and very poorly the reliability was assessed by 15 and 6 persons respectively and 14 persons were not using the city card. The assessment of the access to service outlets in Białystok was assessed slightly worse. Responses to the question are presented in Fig. 2.

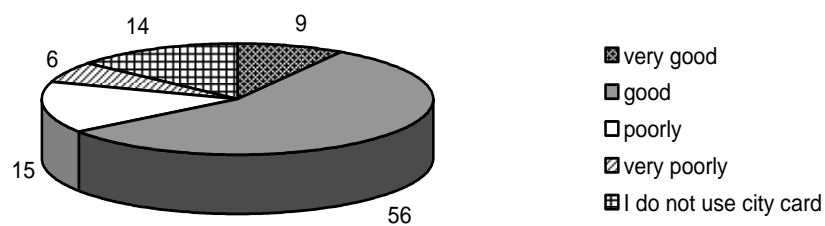


Figure 1. How do you assess the reliability of the city card system in Białystok?

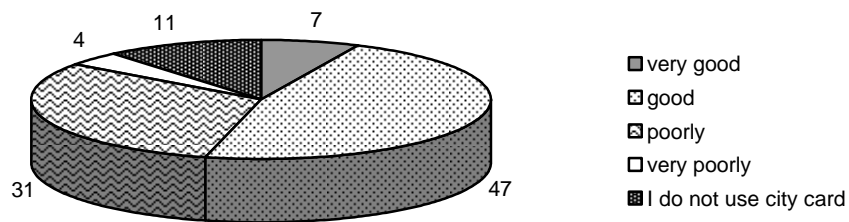


Figure 2. How do you assess the accessibility of customer outlets where the city cards can be recharged?

The largest number of users – as many as 47 responded that the access to customer outlets where the city cards can be recharged was good. 31 respondents stated that the access to such outlets was unsatisfactory. The accessibility of such outlets was defined as very poor by four respondents, as very good by seven with 11 persons answering the questionnaire did not use the city card.

The questionnaire was also aimed at identifying the knowledge of users of the city card functions; therefore, an open question was also asked: Do you know the functions of the city card? The responses are presented in Fig. 3.

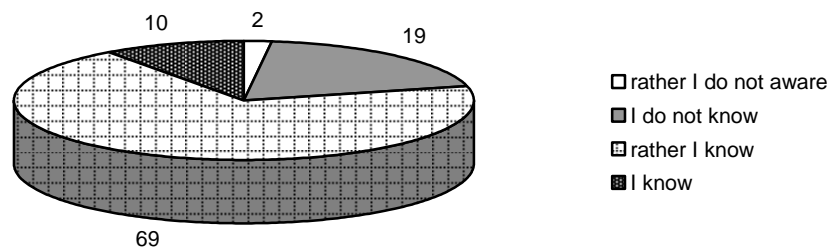


Figure 3. Do you know the functions of the city card?

A large majority of the respondents – as many as 69 thought they were aware of the functions of the city card, 19 had no idea of such functions and two persons stated that they were not aware of the functions. Only 10 persons listed all the functions of the cards.

The next question in the questionnaire was as follows: How do you assess the need to touch the card to the validating machine in a public bus? The results are presented in Fig. 4.

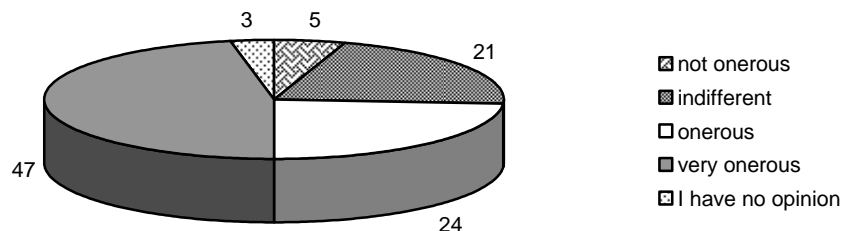


Figure 4. How do you assess the need to touch the card to the validating machine in a public bus?

Only five persons stated that the need to touch the card to the validating machine at entering a public bus was not onerous. A vast majority – as many as 47 persons found the operation as very onerous, 24 as onerous, 21 were indifferent and only three persons had no opinion.

The electronic purse as mentioned earlier is an additional function of the city card. The results of the questionnaire present that it is hardly used by users of public transport (Fig. 5).

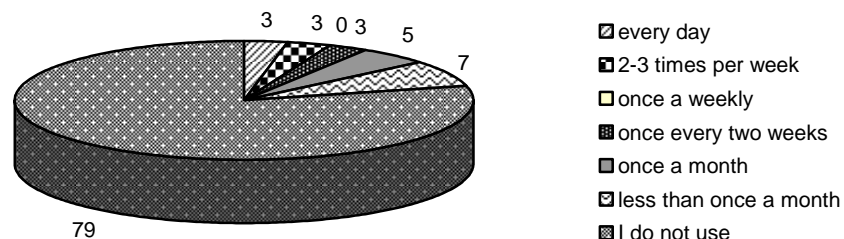


Figure 5. How often have you used the electronic purse function with the city card?

A vast majority – as many as 79 respondents did not use the electronic purse function and only as few as three persons used the function every day. A conclusion is that the function is not very useful for users.

In order to assess the validity of the decision to implement the city card among passengers, the following question was asked: Do you think that the implementation of the city card in Białystok was a right decision? The result is presented in Fig. 6.

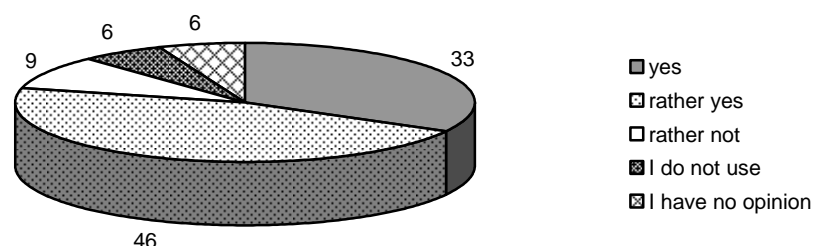


Figure 6. Do you think that the implementation of the city card in Białystok was a right decision?

The responses to the question show that the decision to implement the city card was found as correct by users as it was confirmed by 33 respondents and as a principally right decision by 46 respondents. The decision to implement the system was negatively assessed by six respondents and as a rather incorrect decision by nine persons while six users of public transport had no opinion. Thus, the implementation of the electronic city card in Białystok was positively assessed by users. The fact is further confirmed by another question – for a majority of people (53 respondents), the city card system was more favourable than the earlier system while 29 respondents selected the older system of season paper tickets as more favourable; 15 had no opinion and three persons did not remember the old system. The presented details provide the results to the question: which of the season ticket systems was more favourable for you?

4. Summary

The electronic city card system is a modern solution to improve the management of public transport in many cities, e.g. in Białystok and in Wrocław. The Białystok city card is a system with a lower assessment than the UBRANCARD used in Wrocław since it has less functions integrating various spheres of life of the inhabitants and the system is less advanced.

The proximity city card in Białystok provides access to season tickets containing all the available reductions, it provides for entry to the city stadium, has a possibility to cover functions for large families and the electronic purse function. The city card has many more functionalities than the previous season paper ticket system. The city card system provides for collection of data on passenger routes which ensures better planning of the occupancy of bus lines. However, the new system is more prone to generate errors than the previous one.

An analysis of the responses to the questionnaire by public transport passengers generates a conclusion that despite several deficiencies (e.g. the need to touch the city card to the validation machines at each entry to the bus, an insufficient number of recharging outlets), the inhabitants positively assess the implemented system. A majority of the inhabitants found the electronic city card system as a better solution than the previous season paper tickets.

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