Identification of differences in university e-environment between selected EU and non-EU countries using knowledge mining methods: project IRNet case study

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Abstract: We propose indicators for evaluation of e-environment and evaluation of ICT competences. We analyse data gathered from the research, which was conducted in several European and non-European universities joined in the 7RP project IRNet. One part of the survey was focused on identifying the ways students' use IT tools available in the e-environments of the universities and outlining possible ways for improving educational interactions in a network learning community. We tried to find groups of respondents, which differed in their answers to the questionnaire. We tried to discover knowledge and characterise universities based on the survey results. The most important questions identified in decision rules divide the respondents of the questionnaire into EU students and non-EU students' groups. We found some differences between answers of students which belong to each of these groups. This case study provided an example of further analysis of the survey conducted in several participating countries.

Keywords: knowledge mining; university e-environment; IRNet project; decision trees; questionnaire analysis; e-learning; data mining.

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1 Introduction

One of the common features of modern education in different areas of training is the presence of positions that define the ability to apply e-learning and distance learning technologies in the educational process (Prudencia Gutiérrez et al., 2015). An important aspect of a university graduate is an ability to work in a professional environment with a variety of available information resources, IT tools, and networking opportunities. Information and communication technologies (ICT) are considered today as natural tools for education and professional activities. They quickly progress and are widely used by young generations in different areas of their activities (Morze et al., 2014).

Contemporary educational standards specify the goals and results of training, including a wide range of graduate and professional competences and objectives that a student should be ready to achieve (Kommers et al., 2014).

Regardless of professional activities students are expected to implement, ICT have a high potential to achieve educational outcomes, improve the efficiency of network forms of educational process organisation (Noskova and Pavlova, 2012). To realise this potential, it is necessary to form a system of targeted information and communication educational opportunities, taking into account the benefits of a modern e-environment.

The e-environment of the university should create opportunities for developing the 21st-century competencies as well as for implementing of a lifelong learning strategy. We should emphasise that achieving these aims relates to the effective use of IT tools available in the university e-environment by the students and the teachers. For that reason, it is important to analyse and systematise the main benefits of an e-environment from several stakeholders' points of view. Consequently, such benefits can be evaluated from different perspectives:

- an improvement of educational services quality
- a development of ICT competences
- a formation and a development of competences for the knowledge society
- a formation of graduates' competitiveness.

Seufert and Stanoevska-Slabeva (2002) claimed that online learning can be considered a process that takes place at the intersection of social and technological systems. The link between participants and technology is intertwined with the use of technological platforms as meeting points.

The e-environment of the university constitutes such technological platform and has the patterns of an online learning community, which is defined as learning atmosphere, a context providing a supportive system from which sustainable learning processes are gained through a dialogue and collaborative construction of knowledge by acquiring, generating, analysing and structuring information (Carlén and Jobring, 2005). More precisely, this kind of e-environment has also the characteristics of the knowledge-building online community of practice, because it moves learning processes from the physical space to the virtual realm with newly arisen challenges (Quan-Haase, 2005).

Participants (also called as actors or stakeholders) of this knowledge-building online learning community collaborate based on a common interest as well as practice to share their knowledge and experience. The goals and visions of multiple kinds of participants need to be negotiated. The participants use a mix of different ICT tools for asynchronous as well as synchronous communication while they continuously negotiate how and to what extent a particular ICT tool should be used. ICT tools used for communication are mediated by the language between the participants and their way of talking about the technology as a shared tool (Carlén and Jobring, 2005).

Haythornthwaite (2008) stressed that designing online learning communities is not just a technical or an educational problem, nor it is restricted to the practice of 'teaching' or 'instruction,' but also involves social, technical, administrative, and pedagogical considerations. Knowledge-building online communities can be understood only by considering all these aspects and their design in full.

We mentioned earlier, the relevant as well as regular participants' feedback is evitable for the evaluation process and provides useful information about the stakeholders' overall perception of the available e-environment of the university. The survey represents a very often used and effective technique for gathering such feedback of stakeholders. The survey can provide many answers how effectively stakeholders use e-environment of the university, which services they prefer, which kind of devices or information systems use and many others.

However, beside the analysis of individual questions, we would sometimes like to find different groups of respondents that answered the questionnaire similarly. In this case, we can apply several other knowledge-mining methods, which can help us to find statistically significant results. We provide an example of the application of these methods in this paper. We tried to find differences in students' opinions between several EU countries and non-EU countries, which together actively participated in the FP7 international project IRnet (http://irnet.us.edu.pl/). The members of the project represent a kind of virtual community of practice. They are focused on the development of modern e-environment of the university, which has the characteristics of the knowledge-building online community and takes into account different goals and requirements of the participants.

The paper is structured as follows. The next section describes an e-environment of the university in detail. The third section introduces the methodology and theoretical background of the knowledge mining methods used for evaluating survey results. Consequently, the results of their application are available in the fourth section. The last section provides a discussion of different aspects of obtained results and notes some conclusions how to improve the e-environment of the university.

2 Related work

An electronic environment of the university can be defined as a set of ICT which can contribute to better students' educational outcomes.

E-environment of a university can be considered on several levels. We are achieving educational objectives at the level of course – micro-level. We employ solutions of scientific and educational problems in the corporate environment of the university (interdisciplinary communication, cooperation, exchange of experience) at the meso-level. Finally, we integrate scientific and educational objectives into the external scientific and educational environment at the macro-level (Morze et al., 2015a).

The e-environment and ICT development contribute to the quality of the educational services, to the development of knowledge society competencies and the increase of the competitiveness of an institution in the scientific and educational space. The following conditions must comply to achieve this:

- an electronic environment of the university should be created no less than at advanced level
- a continual improvement of the e-environment of the university and ICT competencies should be performed; the preferred level of competencies is advanced
- changing requirements, determining the competitiveness of an institution in the world scientific and educational space should be considered at every level of the e-environment.

Carlén (2002) defined several typologies of online learning communities based on a rationale like an environment, actors, activities, and tools. According to him, based on the social practices learning can be divided into educational learning, professional learning, and learning by a shared interest.

The use of other two factors, participants, and environment, can further elaborate the participants' activities in practices. The combination of the factors constitutes the basis for constructing a final typology of online learning communities. The environment factor is a condition or arrangement in which online learning communities can be realised in online or blended mode.

There can be three categories of participants, known as main character, managers, and stakeholders. These categories of participants can be understood by their activities, and engagement (Carlén and Jobring, 2005) Participants of online learning community share a conceptual terminology difficult for non-members to understand; therefore becoming a member of an online learning community means exploring the rules for participation and the use of communication as well as web-based and social networking tools (Issa and Kommers, 2013).

According to Preece et al. (2004) the online community, as well as the knowledge-building community, have a purpose, is supported by technology and is guided by policies. We describe two different online communities and their relationship considering rationale mentioned above and requirements. We already introduced the e-environment of the university as a knowledge-building online community in the previous section.

The research was realised as a part of the project IRNet of EU seventh framework program by the consortium of universities. The members of the IRNet project can be considered as another blended community. They represent an example of meta web-based (online) community, because the IRNet itself is a blended community, both face-to-face and web-based. Moreover, we can consider the IRNet community to be a knowledge-based learning community of interdisciplinary researchers and teachers. This kind of community is characterised as a group that is engaged in a process of thinking about knowledge as knowledge (Carlén and Jobring, 2005). According to Haythornthwaite (2008), the participants in a knowledge-building community can be colleagues, researchers or think-tank members. A key challenge for interdisciplinary teams like IRNet is how to put knowledge-bases together, in particular because practices around each knowledge-base are relatively invisible to their practitioners.

Finally, the IRNet community has characteristics of the task-based learning community, which was introduced by Riel and Polin (2004). They proposed task-based learning communities as groups of participants organised around tasks, who work intently together for a specified period to produce a product. These social groups explain project-based communities like IRNet in which the participants have dispersed backgrounds and represent different practices at the beginning of the specific project.

The current state of the e-environment of the university and ICT competences of its stakeholders can be indicated by:

- a range of different types of activities they actively use
- an availability of electronic scientific and educational resources
- a level of network communication in the scientific and educational environment
- the widely accepted management strategies of scientific and educational activities in the e-learning environment of the university.

Morze et al. (2015b) proposed indicators for e-environment and ICT competences evaluation, which can be divided into four groups:

- indicators of university electronic scientific and educational environment (internal, external)
- indicators of e-learning development level
- indicators of student's competencies
- indicators of teacher's competencies.

Comparative analysis of the relation between e-environment of several EU and non-EU universities and indicators of students' competences was described in Morze et al. (2015b). Other groups of indicators of the e-environment development at universities accompanied by the IRNet project are summarised in Pavlova et al. (2016) and Prudencia Gutiérrez et al. (2015).

Drlik and Skalka (2011) described different aspects of the VLE implementation into the e-environment of the university. Capay describes negatives and positives of using e-courses for various groups of students (Capay, 2014). Bílek et al. (2007) describe the web as an effective environment for science and technology education. Some works tried to assess the use of e-environment from the students' point of view and focused on the perception of the VLEs and their impact on the development of ICT competences in the environment of the university. Costa et al. (2012) examined the Moodle of the University of Aveiro (UA) in Portugal through a content analysis, complemented with a non-structured interview carried out with the responsible for the platform at the UA. Afterwards, they analysed Moodle' tools used by students. They used printed questionnaires and assessed three areas: participant characteristics, general use of Moodle and specific Moodle tools. Students were asked about the general purposes of which they used the internet in the learning context. 'E-mail' and 'search' were the most purposes mentioned by the respondents. The 'social networks' were not mentioned in this context. Most students use the Moodle just for downloading materials, only a few of them use Moodle for communicating with the teachers.

The tools used at the UA can be grouped considering the level of importance assigned to them. 'News' and 'assignments' were considered the most important, followed by 'quiz/survey', 'questionnaires', 'forums' and 'Wikis UA', with an intermediate level of importance. Finally, 'chats', 'blogs UA' and 'video-conference' were considered less important.

Barberan et al. (2013) evaluated the use of e-learning at the La Laguna University in Spain. They combined quantitative and qualitative observations. As a common quantitative method, La Laguna University supplies a yearly questionnaire to both teachers and students about the use of the virtual campus, and they monitor the growth of Moodle's resources used on campus. As a qualitative method, they consider the direct observation of teachers and the triangle between assessors and teaching staff. The number of teachers who use e-learning grows each year. However they use the system mainly as a repository, then as the way to submit and receive submissions and discussion forum as the last. They also stated the main problem with their use of e-learning, which was the low level of teaching staff training.

Capay describes the applicability of different types of resources and activity modules in the e-learning courses and the worthiness of their usage and compares the outcomes of data analyses (Cápay et al., 2011; Cápay and Tomanová, 2010).

Mozhaeva et al. (2014) tried to evaluate the use of LMS and Social Networks in the educational process of students and teachers of National Research Tomsk State University, one of the leading universities in Russia. They used the Google Form questionnaire with 68 various questions. Questions were divided into three separate groups. In the first group were participants' general information questions. The second group of questions tried to reveal the relation between students and teachers to various ways of e-learning organisation and to compare it to the traditional face-to-face education. The third group of questions was directed to the definition of use frequency of eight different learning methods in LMS and social networks. A majority of the respondents considers graphical application interface is more convenient for social networks. Moreover, the efficiency, frequency, informational content, interaction, individual approach, cooperation, and emotionality are higher in the social networks than in LMS. However, factors disturbing learning process in Moodle are less visible than in social networks. Results of the research show that the LMS does not provide comparable pedagogical conditions for communication like social networks.

Klocoková (2011) deals with possibilities of using heuristics, interactivity, and feedback in electronic learning materials. Their research presents an experimental evaluation of the efficiency of heuristics approach into learning and a detailed analysis of the user log-on data, on which we can better understand the rate of using of heuristics elements together with other course activities in an electronic learning environment.

Talebian et al. (2014) discuss advantages of e-learning at the university. Main advantages are time and place access, equity, enhancing group collaboration, direct access to resources, enhancing the international dimension of educational services and determination of the progress. They also discuss disadvantages, which are the absence of a teacher, access to unsupportive information, limited feedback from students or unsuitableness in practical courses. They also discuss the conveniences and limitations of e-learning.

There are also several other works, that try to assess the impact of some LMSs, mainly Moodle with other internet services, like e-mail (Benta et al., 2014), SecondLife (Uzun, 2012), Facebook (Deng and Tavares, 2013). More of them stated that LMS and other IT Tools significantly contribute to improving students' learning outcomes. Moreover, they emphasise the importance of the continual development of e-environment of the university using IT tools, which should be in line with the expectations and everyday habits of the students.

3 Research

As we mentioned earlier, we would like to apply a knowledge mining methods on the dataset, which represents the students' answers to the survey realised during the work package 3 of the IRNet project (http://irnet.us.edu.pl/).

The survey pursued following aims:

- to determine if students understand the opportunities and educational benefits of e-environment
- to identify an expansion of space-time coordinates, personalisation of educational activities as well as individual request
- to increase the degree of educational openness.

The survey was realised in the form of questionnaire at several EU and non-EU universities – the participants of the 7RP IRNet project: Herzen State Pedagogical University of Russia, St. Petersburg (HSPU), The University of Silesia in Katowice (US), Borys Grinchenko Kyiv University (BGKU) and Constantine the Philosopher University in Nitra (UKF), Slovakia.

The questionnaire consisted of 14 questions creates the basis for the evaluation of university e-environment. We assumed that participants of e-environment (academic teachers, students, administration) are involved in activities with the following benefits (group of questions = effects):

Effect 1 Expansion of space-time coordinates (an increase of scientific and educational processes comfort, focus on lifelong learning goals (Q1, Q2, Q3).

Effect 2 Personalisation of educational activities, individual request in e-learning (Q4, Q5).

Effect 3 Formation of new scientific and educational relations, cooperation, intercultural competence (Q6, Q7, Q8, Q9).

Effect 4 Empowerment of self-realisation in educational and professional activities, support of initiatives (Q10, Q11).

Effect 5 Increase of the openness degree of the scientific and educational environment, expanding the influence of the university to the external cultural environment; positioning of the actors in the research and education community (Q12).

Effect 6 Enhancing self-organisational effects that support the sustainable development of the educational environment of the university and its participants (Q13, Q14).

We analysed data gathered in the survey to identify the ways students' use the IT tools in the e-environments of the universities and to outlined possible ways for improving educational interactions in a network learning community.

The data did not provide only the basis for determining the readiness of students for self-guided learning and identifying the preferred activities in the e-environment. Moreover, it can also help identifying ways how to improve the e-environment of the university.

The results of the survey confirmed that the perception of the usefulness of the e-environment of the university and the level of ICT skills depend on several conditions (Svec et al., 2015):

- the degree of e-environment development (virtual space-electronic resources and information technology; interactions while solving scientific and educational problems)
- the level of competences of the main groups of e-environment stakeholders (faculty members, students, staff responsible for e-environment management).

These results provided interesting findings at the level of individual effects and were suitable for mutual comparison of the universities. At the same time, the results of the survey evoked us to find the answer to the question, in what are the opinions, which divide the respondents into groups. Moreover, we would like to identify homogeneous groups created from these questions, which engaged the students in the same manner.

The application of the next knowledge discovery methods to the dataset of survey results contributed to answering these questions.

3.1 Decision trees

The purpose of the decision trees is to classify some objects into classes in general. The basic approach to generate a decision tree consists of selecting attributes for sub-tree nodes and subsequent separation of data into subsets according to this attribute. If not all data in one subset belongs to one class, we choose another attribute for splitting the subset. There are many algorithms to create decision trees. They vary in a way that they choose the attribute for the sub-node. The one possibility is to select a node using the entropy employing the J48 algorithm. The entropy value is calculated for each node and represents the level of subset disorder.

3.2 Entropy

According to Grosan and Abraham (2011), putting together a decision tree is all a matter of choosing which attributes to test at each node in the tree. If this attribute is not clear, we shall define a measure called information gain, which will be used to decide which attribute to test at each node. Information gain is calculated itself using a measure called entropy, which we first define for the case of a binary decision problem and then define for a general case.

Given a binary categorisation C, and a set of examples S, for which the proportion of examples categorised as positive by C is p_P and the proportion of examples categorised as negative by C is p_N, then the entropy of S is:

$$Entropy(S) = -p_P \log_2(p_+) - p_N \log_2(p_-)$$

We defined entropy first for a binary decision problem because it provides an easier way to get an impression of what we are trying to calculate.

Given an arbitrary categorisation C into categories $c_{1,}\ldots,c_n$, and a set of examples S, for which the proportion of examples in c_i is p_i, then the entropy of S is:

$$Entropy(S) = \sum_{i=1}^{n} -p_i \log_2(p_i)$$

We now return to the problem of trying to determine the best attribute to choose for a particular node in a tree. The following measure calculates a numerical value for a given attribute A, with respect to a set of examples S. Note that the values of attribute A will range over a set of possibilities, which we call *Values*(A), and that, for a particular value from that set v, we write S_v for the set of examples, which have value v for attribute A. The information gain of attribute A, relative to a collection of examples S, is calculated as:

$$Gain(S, A) = Entropy(S) - \sum_{v \in Values(A)} \frac{|S_v|}{S} Entropy(S_v)$$

The information gain of an attribute can be seen as the expected reduction in entropy caused by knowing the value of attribute A.

3.3 Algorithm J48

Decision trees represent a supervised approach to classification. A decision tree is a simple structure where non-terminal nodes represent tests on one or more attributes, and terminal nodes reflect decision outcomes. Quinlan (1987) has popularised the decision tree approach with his research spanning more than 15 years. The latest public domain implementation of Quinlan's model is C4.5.

C4.5 builds decision trees from a set of training data using the concept of information entropy. The training data is a set $S = s_1, s_2, \ldots$ of already classified samples. Each sample $s_i = x_1, x_2, \ldots$ is a vector, where $x_1, x_2, \ldots$ represent attributes or features of the sample. The training data is augmented with a vector $C = c_1, c_2, \ldots$ where $c_1, c_2, \ldots$ represent the class to which each sample belongs. At each node of the tree, C4.5 chooses one attribute of the data that most effectively splits its set of samples into subsets enriched in one class or the other.

The normalised information gain (difference in entropy) is the criterion that results from choosing an attribute for splitting the data. The attribute with the highest normalised information gain is chosen to make the decision. The C4.5 algorithm then passes recursively on the smaller sub lists (Quinlan, 1993).

The Weka classifier available in KNIME has its own version of C4.5 known as J48. The algorithm is applied to the training data. The created decision tree is tested on a test dataset, provided one is available. If test data is not available, J48 performs a cross-validation using the training data. The confusion matrix is simply a square matrix that shows the various classifications and misclassifications of the model in a compact area. The columns of the matrix correspond to the number of instances classified as a particular value and the rows correspond to the number of instances with that actual classification (Mohanty et al., 2010).

3.4 Research methodology

The general research methodology consists of the following steps.

1 create and deliver questionnaire

2 gather responses

3 pre-process results for statistical analysis

4 create decision tree to identify decision rules

5 identify the most important rules

6 concept characteristic.

4 Results

We analysed pre-processed results using decision trees according to the listed steps of methodology. We tried to find groups of respondents, which differed in their answers to the questionnaire.

The researchers from the Herzen State Padagogical University in St. Petersburg, Russia created a questionnaire, which was further improved and discussed by other universities in the IRNet project.

The final version of the questionnaire was translated into the native language of each country and then delivered to the university students by Google Forms (expect Poland, where researches used LimeSurvey). Each university had to get responses from at least 100 students.

Some questions of the questionnaire were multiple choices, some others not. For the purpose of further analysis using methods mentioned above, we needed to transform all answers into true/false question. For that reason, we created sub-questions by this transformation, e.g., the Q3 became Q3-1, Q3-2, … Q3-6.

4.1 Decision trees

We created the decision tree using the classification algorithm J48 as the first step. The classes were represented by the universities. Properties of the tree can be seen in Table 1.

The created tree had only 8.99% of incorrect classifications. In the first step, we tried to create a tree with all questions of the questionnaire conducted at five universities. However, we got a quite large one. We needed to find the characteristics of the students of each university, and this was not possible with the large size tree.

Table 1 Properties of the decision tree

Classes	*Number of leaves*	*Size of the tree*	*Correctly classified instances*	*Incorrectly classified instances*
UKF, OU, US, BGKU, HSPU	112	216	790 (91.01%)	78 (8.99%)

For that reason, we created other decision tree using a J48 algorithm according to the groups of the question, which we call ‘effects’. The questionnaire finally consisted of six effects. We wanted to find simpler trees, which can describe students’ opinions in a cleaner way. We present properties of the decision trees for different effects in Table 2.

Table 2 Properties of decision trees according to the effects

Effect	*Classes*	*Number of leaves*	*Size of the tree*	*Correctly classified instances*	*Incorrectly classified instances*
Effect 1	UKF, OU, US, BGKU, HSPU	63	113	617 (71.08%)	251 (28.92%)
Effect 2	UKF, OU, US, BGKU, HSPU	5	9	448 (51.61%)	420 (48.39%)
Effect 3	UKF, OU, US, BGKU, HSPU	38	75	497 (57.26%)	371 (42.74%)
Effect 4	UKF, OU, US, BGKU, HSPU	78	155	595 (68.55%)	273 (31.45%)
Effect 5	UKF, OU,US, BGKU, HSPU	27	53	442 (50.92%)	426 (49.08%)
Effect 6	UKF, OU,US, BGKU, HSPU	1	1	340 (39.17%)	528 (60.83%)

The greatest surprise was that created trees showed a high percentage of badly classified cases. For example, when we look at the effect 6, we can see that 60.83% of all cases were misclassified. These trees, where we used the concept of effects, have not been used for further analysis because there was a high error rate of classification.

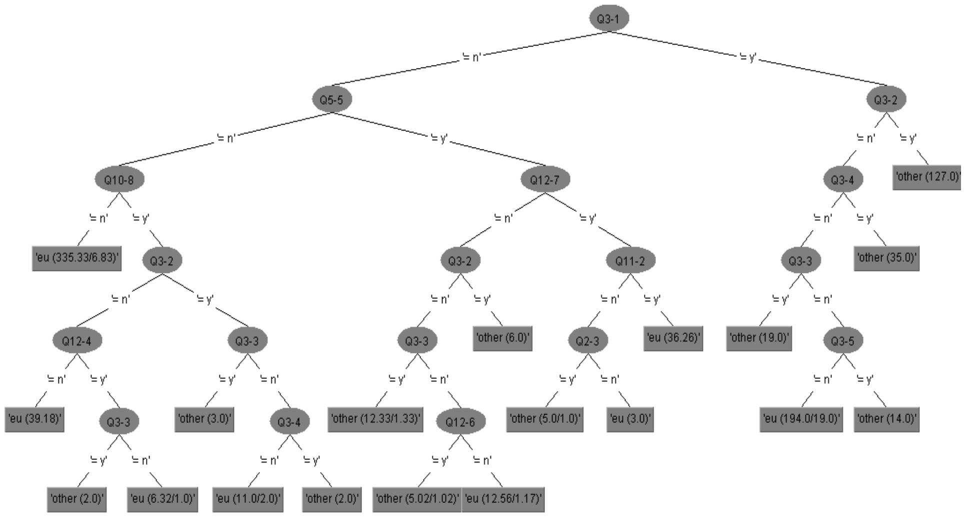
When we considered the entire questionnaire comprehensively, we got the low number of misclassified cases. However, the large tree was created. For that reason, we decided to create another decision tree for a classification of data into only two classes to reduce the size of the final tree.

We defined a class *EU* in which we included data collected from the universities UKF, OU as well as the US. Subsequently, we defined a class *non-EU*, which included data from the universities BGKU and HSPU. Properties of the decision tree can be seen in Table 3 and the final decision tree in Figure 1.

Table 3 Properties of the decision tree with just two classes of the universities

Classes	*Number of leaves*	*Size of the tree*	*Correctly classified instances*	*Incorrectly classified instances*
EU, non-EU	19	37	835 (96.20%)	33 (3.80%)

Figure 1 The complex tree with just two classes – *EU* and *non-EU*



4.2 Decision rules

When we transcript created a tree, we get decision rules. One decision rule belongs to each row of Table 4. We can explain the meaning of these rules in the following example.

$$(Q3-1=n) \text{ and } (Q5-5=n) \text{ and } (Q10-8=n) \Rightarrow EU$$

The third question (Q3) aimed to the students' self-development, self-realisation in a research and scientific activities was 'choose the most important from your point of view indicators of the comfort of the electronic environment of the university'. Student was able to select from these options:

Q3-1 Availability of Wi-Fi access points.

Q3-2 Opportunity to use own gadgets.

Q3-3 Availability of electronic educational resources in different formats (video, audio, hypertext, etc.).

Q3-4 University website with the relevant information for students and comfortable navigation.

Q3-5 Availability of distance support for disciplines (tasks in electronic form, electronic journal, discipline's website or Moodle).

Q3-6 Availability of fast feedback from a teacher.

Table 4 Decision rules and their properties

Decision rules			*Correctly classified*	*Incorrectly classified*
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *n*)	=>	*EU*	330	6
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *n*) and (Q12-4 = *n*)	=>	*EU*	36	
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *n*) and (Q12-4 = *y*) and (Q3-3 = *y*)	=>	*Non-EU*	2	
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *n*) and (Q12-4 = *y*) and (Q3-3 = *n*)	=>	*EU*	5	1
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *y*) and (Q3-3 = *y*)	=>	*Non-EU*	3	
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *y*) and (Q3-3 = *n*) and (Q3-4 = *n*)	=>	*EU*	10	2
(Q3-1 = *n*) and (Q5-5 = *n*) and (Q10-8 = *y*) and (Q3-2 = *y*) and (Q3-3 = *n*) and (Q3-4 = *y*)	=>	*Non-EU*	2	
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *n*) and (Q3-2 = *n*) and (Q3-3 = *y*)	=>	*Non-EU*	11	1
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *n*) and (Q3-2 = *n*)and (Q3-3 = *n*) and (Q12-6 = *y*)	=>	*Non-EU*	4	1
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *n*) and (Q3-2 = *n*) and (Q3-3 = *n*) and (Q12-6 = *n*)	=>	*EU*	11	1
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *n*) and (Q3-2 = *y*)	=>	*Non-EU*	6	
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *y*) and (Q11-2 = *n*) and (Q2-3 = *y*)	=>	*Non-EU*	4	1
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *y*) and (Q11-2 = *n*) and (Q2-3 = *n*)	=>	*EU*	3	
(Q3-1 = *n*) and (Q5-5 = *y*) and (Q12-7 = *y*) and (Q11-2 = *y*)	=>	*EU*	36	
(Q3-1 = *y*) and (Q3-2 = *n*) and (Q3-4 = *n*) and (Q3-3 = *y*)	=>	*Non-EU*	19	
(Q3-1 = *y*) and (Q3-2 = *n*) and (Q3-4 = *n*) and (Q3-3 = *n*) and (Q3-5 = *n*)	=>	*EU*	181	19
(Q3-1 = *y*) and (Q3-2 = *n*) and (Q3-4 = *n*) and (Q3-3 = *n*) and (Q3-5 = *y*)	=>	*Non-EU*	14	
(Q3-1 = *y*) and (Q3-2 = *n*) and (Q3-4 = *y*)	=>	*Non-EU*	32	
(Q3-1 = *y*) and (Q3-2 = *y*)	=>	*Non-EU*	127	

The fifth question (Q5) 'what additional electronic educational services would you like to receive at your university?' consists of the following options:

Q5-1 Studying foreign languages.

Q5-2 Acquiring an additional profession.

Q5-3 Learning about start-ups and own business.

Q5-4 Other.

Q5-5 Additional occupation.

The tenth question (Q10): choose the reasons motivating you to demonstrate in the electronic university environment the results of your academic, artistic, sporting activities (on the university web-site, in social networks, etc.):

Q10-1 Opportunity to present myself and my achievements to others.

Q10-2 Opportunity to be noticed by a potential employer

Q10-3 Prerequisite of studying a particular discipline.

Q10-4 General interest.

Q10-5 Own status upgrade.

Q10-6 Opportunity to make new friends.

Q10-7 I do not want to show myself and my achievements to others because I have nothing to show.

Q10-8 I do not want to show others my achievements and myself because I am not interested in it.

The decision rule says that the students, who do not agree with the Q3-1, Q5-5, and Q10-8, are classified as *EU* students. There are 330 correctly classified respondents and just 6 incorrectly classified respondents.

We had to choose the most important rules (with the highest number of correctly classified rules) from the created decision tree. The most important rules of the *EU* class can be seen in Table 5.

Table 5 The most important rules for the *EU* class

Decision rules			*Correctly classified*	*Incorrectly classified*
(Q3-1 = n) and (Q5-5 = n) and (Q10-8 = n)	=>	*EU*	330	6
(Q3-1 = y) and (Q3-2 = n) and (Q3-4 = n) and (Q3-3 = n) and (Q3-5 = n)	=>	*EU*	181	19

We can classify 79.72% of students, which belong to the *EU* class according to these rules and thus see the nature of their opinion. The most important question for them was the third one (satisfaction with the VLE of the university). We can see that students, which did not select the sub-question Q3-1 (availability of the WiFi connection) also did not agree with the Q5-5 (Additional occupation) and Q10-8 (I do not want to publish anything about me).

On the other hand, when they selected the Q3-1 sub-question they did not consider relevant (they did not choose) other choices in the third question Q3-2 (use of own devices), Q3-3 (availability of e-resources), Q3-4 (university website with relevant information), Q3-5 (distance support).

The rules, which classify students into the class *non-EU,* can be seen in Table 6. We can classify 159 students based on these rules. This number of students represents 70.04% of all students in the *non-EU* class. The most important question was the third one (VLE of the university), actually the first choice Q3-1 (availability of WiFi). One hundred twenty-seven students (55.95% of all students in *non-EU* class) chose both Q3-1

(WiFi) and Q3-2 (opportunity to use own gadgets). Students who chose the Q3-1 (WiFi) option and did not choose the Q3-2 (own devices) than also chosen the Q3-4 (university website).

Table 6 Rules for the class *non-EU*

Decision rules			*Correctly classified*	*Incorrectly classified*
(Q3-1 = y) and (Q3-2 = n) and (Q3-4 = y)	=>	*Non-EU*	32	
(Q3-1 = y) and (Q3-2 = y)	=>	*Non-EU*	127	

4.3 Concept description

Decision trees were created based on the data gathered from the students' responses to the questionnaire. We tried to discover knowledge and characterise universities based on the survey results.

The most important questions identified in decision rules (Table 5 and Table 6) divide the respondents of the questionnaire into *EU* students and *non-EU* students' groups.

Subsequently, we could apply other knowledge discovery method, which was based on the 'concept description' using the decision rules. In the presented case study, the universities represented two concepts – *EU* and *non-EU*. The questions in the questionnaire represented the in-group factor and *EU*, *non-EU* represented the intergroup factor.

The equality of the variances and covariances in a covariance matrix for repeated measures represent a prerequisite for the analysis of variance with repeated measures. This assumption is called the sphericity condition of the covariance matrix. We used the Mauchley'ssphericity test (Table 7) to verify the assumption for the analysis of variance for repeated measures with more than two levels. We state that the assumption was violated if the test was significant. The validity prerequisite was violated in our case.

Table 7 The sphericity condition of the covariance matrix for repeated measures Q (Q3-1, Q3-6)

	W	*Chi-sq.*	*df*	*p*
Q	0.8915	97.8976	20	0.0000

Notes: W – test statistics, chi-sq – chi-square test statistics, df – degrees of freedom, p – significance value.

Unless the sphericity condition of the covariance matrix is fulfilled, error type I is increasing. This is a reason why the degrees of freedom for used F-test are modified using adjustments in such cases (greenhouse-Geisser and Huynh-Feldt adjustments), and then the declared significance level is achieved. The results of unmodified analysis of variance are in the first three columns of Table 8. Modified results are in the others. We can see that the results are identical.

Table 8 Modified significant tests for repeated measures Q (Q3-1, Q3-2, Q3-3, Q3-4, Q3-5, Q3-6)

	f	*F*	*p*	*G-G*	*G-G*	*G-G*	*G-G*	*H-F*	*H-F*	*H-F*	*H-F*
				Eps	*Adj df1*	*Adj df2*	*Adj p*	*Eps*	*Adj df1*	*Adj df2*	*Adj p*
Q	6	50.3324	0.0000	0.9624	5.7745	4,937.1982	0.0000	0.9708	5.8250	4,980.3837	0.0000
Q * category	6	19.7383	0.0000	0.9624	5.7745	4,937.1982	0.0000	0.9708	5.8250	4,980.3837	0.0000

Notes: df – degrees of freedom, F – test statistics, p – significance value, Eps – epsilon test statistics, Adj df1 – adjusted degrees of freedom 1, Adj df2 – adjusted degrees of freedom 2, Adj p – adjusted significance value, G-G – greenhouse-Geisser adjustment, H-H – Huynh-Feldt adjustment.

Null hypotheses make a claim that there is no statistically significant difference in the identified items score (based on the decision trees) (Q3-1, Q3-2, Q3-3, Q3-4, Q3-5, Q3-6), and their score does not depend on the studied concepts (*EU*, *non-EU*). We tested these hypotheses at the 5% significance level.

As a result, null hypotheses, which make a claim that there is no statistically significant difference in the identified items score (Q3-1, Q3-2, Q3-3, Q3-4, Q3-5, Q3-6), were rejected with at the 5% significance level (Table 8). We confirmed that the studied concepts (*EU*, *non-EU*) did not affect the score of items.

After global hypotheses rejecting we were wondering if there were statistically significant differences among studied concepts' items.

We applied multiple comparisons (LSD test, Table 9) to identify homogenous groups and to identify statistically significant differences.

Table 9 Homogenous groups identification according to the studied concepts (*EU*, *non-EU*)

Category	*Q*	*M*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
EU	Q3-2	0.128	****						
EU	Q3-3	0.138	****						
EU	Q5-5	0.139	****						
EU	Q3-5	0.139	****						
EU	Q10-8	0.149	****	****					
EU	Q3-4	0.189		****					
EU	Q3-1	0.287			****				
Non_EU	Q10-8	0.299			****				
Non_EU	Q3-5	0.378				****			
Non_EU	Q3-3	0.417				****	****		
Non_EU	Q3-4	0.453					****		
Non_EU	Q5-5	0.555						****	
Non_EU	Q3-2	0.567						****	
Non_EU	Q3-1	0.835							****

Notes: M – mean, 1 – the first homogenous group,…, 7 – the seventh homogenous group.

We identified seven homogeneous groups using multiple comparisons (Table 9). Most sub-questions, which occurred in the homogeneous groups, are from the third question.

There are three such groups within the *EU* concept. The first group does not overlap just with the third one. The meaning of the first group is that students from *EU* concept lay the same focus on Q3-2, Q3-3, Q5-5, Q3-5 and Q10-8 and there is no statistically significant difference in these answers.

We identified statistically significant difference in the score of items on both studied concepts (EU, non-EU), except items Q3-1 and Q10-8, which form a single homogenous group.

The question Q3-1 (Wi-Fi) forms a separate group of both concepts (*EU* and *non-EU*). The mean value of score shows that this question is for students the most important one. This question is the only one in the EU concept, which creates a non-overlapping homogenous group with the first group.

Responses of students within the *non-EU* concept form five separate groups. There are no statistical differences among answers within the group. Students of each group pay the same attention to the answers, and there are no statistical differences between these answers.

We looked for groups of the question, which did not overlap. For example, the group 4 did not overlap with the groups 3, 6, 7 in the non-EU concept part of Table 9.

Student, who selected the question Q3-3 (availability of electronic educational resources in different formats (video, audio, hypertext, etc.), paid the same attention to the question Q3-5 [availability of distance support for disciplines (tasks in electronic form, electronic journal, discipline's website or Moodle)]. There is no statistically significant difference between these two answers.

Figure 2 The average and 95% confidence interval graph for identified items in the studied concepts (*EU, non-EU*) (see online version for colours)

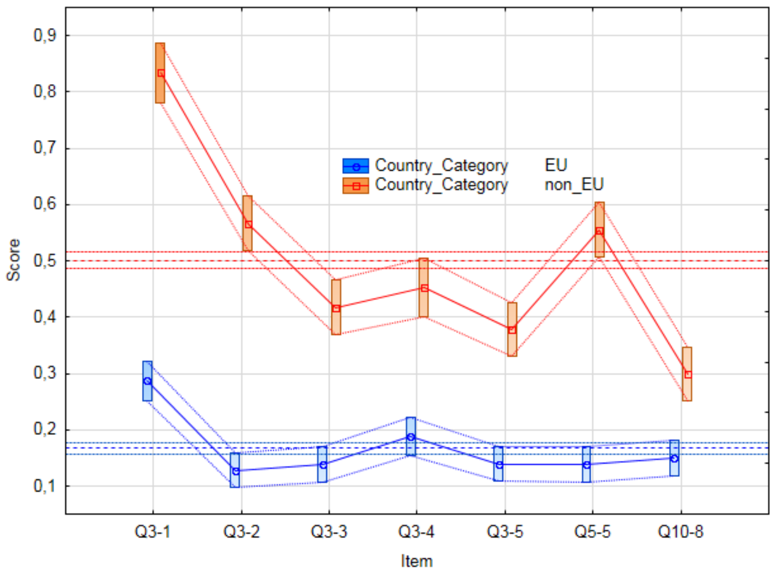


Figure 2 visualises the point and interval estimation of the mean scores of items identified in the studied concepts.

The items Q3-1, Q3-2 and Q5-5 within the *non-EU* concept (Figure 2) achieved the above-average score. The items Q3-1 and Q3-4 within the EU concept (Figure 2) also achieved the above-average score.

Identified items characterise the *EU* concept by the low score. On the contrary, a high score is characteristic for the countries outside the EU, while there were demonstrated statistically significant differences between the studied concepts for the corresponding items.

5 Conclusions and discussion

We dealt with the results of the questionnaire, which analysed the e-environment of the university from the students' point of view. We assumed that they are involved in activities with the following benefits:

Effect 1 Expansion of space-time coordinates (an increase of scientific and educational processes comfort, focus on lifelong learning goals (Q1, Q2, Q3).

Effect 2 Personalisation of educational activities, individual request in e-learning (Q4, Q5).

Effect 3 Formation of new scientific and educational relations, cooperation, intercultural competence (Q6, Q7, Q8, Q9).

Effect 4 Empowerment of self-realisation in educational and professional activities, support of initiatives (Q10, Q11).

Effect 5 Increase of the openness degree of the scientific and educational environment, expanding the influence of the university to the external cultural environment; positioning of the actors in the research and education community (Q12).

Effect 6 Enhancing self-organisational effects that support the sustainable development of the educational environment of the university and its participants (Q13, Q14).

If we look at the information gain of individual questions and sub-questions, we can conclude several interesting remarks regarding the observed effects defined in the questionnaire. Considering the results of the application of decision tree methods, we can assume, that the students of both groups answered similarly to the questions included in all effects except the effect 1. There was not identified the question, which should be answered differently in EU and non-EU group of students.

The most interesting group of questions belong to the effect 1. It is surprising that the availability of Wi-Fi (Q3-1) is considered the most important indicator of the comfort of the stakeholders of the e-environment of the university, which divide the EU and non-EU groups of students into groups. The stable and ubiquitous Wi-Fi, as well as the possibility to use owns mobile devices or gadgets (Q3-2) represent a gateway to other IT services of the university.

The found difference indicates that EU students do not consider the availability of Wi-Fi (Q3-1) the most important benefit of the e-environment, as well as the use of their gadgets (Q3-2). These indicators had not impact on the use of available electronic educational resources in different formats (Q3-3), information from the university website (Q3-4) as well as the availability of distance support like VLE, OEM, etc. (Q3-5).

On the other hand, the non-EU students consider the use of their own devices in the Wi-Fi university network as well as information published on the university website the same important. This finding is in the line with the results of the previously realised qualitative analysis of the e-environment of the universities accompanied by the project. The non-EU universities prefer to integrate all the IT services directly to the university websites. The non-EU students consider the website of the university as a place, where they are looking for educational resources. They probably identify other IT services with the website of the university.

Selecting a given algorithm of the decision tree methods for classification of the cases caused mainly informative value of the found decision rules. However, several common decisions of the students show that the EU students would welcome closed cooperation between university and enterprises as well as additional electronic educational services about the job offers. This finding is in the line with the trend to create a closer connection between universities and enterprises.

After identification of decision rules, we consequently identified statistically significant differences, e.g., homogenous groups of questions, among studied concepts' items using multiple comparisons (Table 9).

The first homogeneous group also confirms the fact, that the EU students predominantly use Wi-Fi to login into the e-environment.

The second homogeneous group of questions affirmed the EU students use VLEs and other systems, which provide educational resources supporting the learning process. The third group indicates that EU students devoted the same interest showing their achievements on the website of the university. We consider the fact they consider showing their achievements and themselves to others surprising because they are not interested in it. They paid the same attention to all these questions.

There is a statistically significant difference between the first homogeneous group of questions focused on publishing students' achievements (Q10-8) and group (Q3-3, Q3-5), which represents using of educational resources in the concept of non-EU students. They paid the same attention to the questions about the availability of educational resources (Q3-3, Q3-5) as well as the information content of the university website (Q3-3, Q3-4).

The application of knowledge discovery methods uncovered several small inconsistencies in the translations of the questionnaire questions to the native languages of the respondents. However, these inconsistencies did not affect the results of these methods.

This case study provided an example of further analysis of the survey, which was conducted in several participating countries. We tried to explain the possible interpretation of the findings. Moreover, we suppose the way, how can we focus further research, if we would discover the differences between the groups of respondents.

We dealt with two different communities and their relationship from the web-based community theory point of view. A task-based and interdisciplinary character of the IRNet community represents an interesting contemporary case of knowledge-building communities, which is created by several university teams. Observation and research of such groups show the way the practice is entwined with knowledge (Haythornthwaite, 2008). The selection of research methods and practice, the topics of common publications, the creation of a new methodology, as well as the questions how and whether data can be shared, all represent quite important issues, which should be continually solved. Therefore, we can agree with Haythornthwaite, that the relation that needs to work for such community is not so much knowledge sharing, or personal social interaction, but instead a joint articulation of differences. Moreover, what such knowledge-building community learn is practice, and what is enacted by this community through these kinds of experiences, is collective knowledge about how to practice in such diverse groups of university teams.

Smaller discrepancies among IRNet project's university partners can be mitigated or even solved using common strategies and negotiation approaches. Even though the blended character of the IRNet community anticipates intensively using of ICT tools, predominantly, essential as well as principled decisions are made easily during the face-to-face meetings. Therefore, we can emphasise the importance of regular personal meetings and exchange of knowledge in the form of staff exchange. Surprisingly, this approach remains more effective irrespective of the available ICT and social networking tools. At the same time, this is a reason, why an acceptance or rejection of a new member of a community depends mostly on the consent to the main aims, didactic approaches, and methodologies, used by the knowledge-based community. We can consider the importance of the compatibility of the ICT tools only secondary because the shared knowledge should not depend on the particular technology.

The participants of IRNet community work intently together for a specified period to produce a new methodology and recommendation for development of modern e-environment of the university. The participants have the dispersed backgrounds and represent different practices at the beginning of the specific project. Participants, who take part in constructing such online as well as blended learning communities, create a group of people, who share the same ideas, construct common values, display disagreements, and formulate goals and purposes in the collaborative learning (Haythornthwaite, 2008). It does not always mean that participants are also involved in the learning activities itself. Therefore is essential to take into account the opinions and expectations of the future participants of the knowledge-based community, which is represented by the university e-environment in our case.

For that reason, the participants of the IRNet community prepared and analysed the survey for the potential future participants of the online learning community represented by the teachers and students. The survey represents an example, how can different communities adjust their goals and ideas.

We can conclude considering the obtained results of the survey that the involvement of the participants of both communities represents the most important aspect of successful transferring of the knowledge between two different typologies of communities. The students did not exactly know in many cases, what they should expect from the modern university e-environment. This is probably the reason that the most interesting results deal with the Wi-Fi connection and availability of the university website. They have not enough information, how the e-environment could help them in the learning process, how they could utilise social network activities to learn collaboratively, or why it is necessary to promote their personal achievements to the potential employers.

Therefore, we propose, that the next research, as well as discussion in the knowledge-based community of university teams like IRNet, could be focused on better understanding of the preferences in the virtual communication of the students in the social networks, identifying the learning motivation factors and improving the used learning methodologies, all in the frame of the developed university e-environment.

The future work should focus on the further analysis of the cultural differences and IT implementation strategies between EU and non-EU universities. Moreover, it should be focused on the open questions about the effective communication between different typologies of the communities, sharing and transferring the knowledge, adjusting their different goals, selecting of appropriate ICT and social networking tools as well as adapting the virtual environment to their behaviour.

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