VIRTUALIZATION OF UNIVERSITIES. THE NETWORK PERSPECTIVE

SUMMARY

Ph.D. Thesis by Tomasz Gładysz

The aim of this thesis is to develop a model of university's virtual maturity, allowing to assess the level of virtualization of a university jointly, in all its spheres of activity, i.e., in the didactic (educational) sphere, in the sphere of scientific research, and in the sphere of administration. The original solution was named University Virtual Index of Maturity (UVIM) and is based on a well-known and widely accepted pattern of maturity models with a five-point scale. According to the results of the study [Kosieradzka and Smagowicz, 2016], the vast majority of maturity models are characterized by the number of maturity levels oscillating between four and six, with five maturity levels prevailing in most cases.

Bearing in mind the perceived research gap in the form of the lack of a comprehensive approach to university virtualization in the literature, and in particular the lack of a university virtualization model, the following research question has been formulated, which is attempted to be answered in this dissertation:

After recognizing in what areas, in what stages, and under what conditions the virtualization of universities takes place, can a theoretical model of university's virtual maturity covering the networking of all areas of its activity be developed and applied in practice to assess the level of university's virtual maturity?

The following objectives have been derived from the above:

Main Objective:

The aim of the work is – based on the identification of areas, stages, and conditions of virtualization of a university in the network – to develop, implement and test a university's virtual maturity model on selected case studies.

Cognitive goal:

Analysis of the current state of research on university virtualization, recognition of the Internet environment as a network environment indispensable for the virtualization process, and identification of conditions and limitations of virtualization.

Methodological goal:

Identification of individual areas of the university's activity, determining the number of virtual maturity levels in the identified areas, and determining the ways of assigning individual virtual maturity levels.

Utilitarian goal:

Application of the created model to assess the current level of virtualization of selected universities and, depending on the availability of archival data, to assess the change in the level in relation to previous years.

The objectives formulated in this way and the research problem have become the starting point for formulating the following hypothesis:

It is possible to create a university' virtual maturity model, serving as a tool to assess the current state of university virtualization.

The dissertation consists of seven chapters, reflecting the subsequent activities carried out as part of the assumed plan of the research procedure.

The first chapter is devoted to introducing the necessary conceptual apparatus, discussing various approaches to virtuality, and indicating the approach to the issue from the network perspective, and presenting information technology as a necessary element to carry out the virtualization process. It opens with definitions of virtuality presented in the literature on the subject matter, together with an indication of the definition adopted for consideration in this dissertation and closes with a discussion of the Internet environment. The concept of virtualization and virtual organization has been discussed in the literature for many years. However, it is not strictly defined. There are many definitions which differently emphasize the relevance of an object's properties for classification in the "virtual" group. Perechuda [1997] defines a virtual organization as a modern organizational model that optimizes the play on intangible resources [Perechuda, 1997]. The idea of a virtual organization is expressed in the form of multifaceted and multifactor system transformations taking place in various economic entities. These transformations are aimed at eliminating inefficient supply channels, reducing extended routes of information flow, and transforming sluggish hierarchies into flexible organizational units with high autonomy and a high standard of activities in the field of operative management of widely understood production and work [Niedzielska, 1997]. Kisielnicki [1998] claims that a virtual organization is based on the voluntary participation of members who enter various new types of relationships with each other in order to achieve greater benefits as compared to those gained from traditional cooperation. According to Olejczyk [2000], a virtual organization is a company that

operates in computer networks (internet) or that, in addition to functioning in the traditional market, also conducts activities (mainly sales and promotional ones) in the virtual market. Also, a virtual organization is a dynamic management tool based on computer networks and on the possibilities of using information banks, such as the internet, among others, which is ideal for achieving competitive advantage in the global market [Grudzewski & Hejduk, 2002].

Some of these definitions (i.e., by Perechuda, by Niedzielska, by Kisielnicki) focus on the structure, emphasize the loosening of ties, and the ability to modify quickly, define this state as cooperation of independent units with high (if not total) autonomy. Due to legal requirements, university structures must remain within certain clearly defined limits imposed by regulations (including, among others, the Law on Higher Education, and any implementing regulations). Therefore, it is difficult to talk only about juxtaposed various configurations – in response to the demand – of forms of cooperation of completely independent and autonomous entities.

Virtual space is derived from selected components of other spaces. According to Warner and Witzel [2005], the virtual space is created by:

− imaginative space,
− technological space,
− cultural space.

While analyzing selected definitions in the context of university's virtual maturity, it may be concluded that the approach best suited to this specific situation is the one focusing, in the initial stages, on the use of information technology and the internet and, in later, more advanced stages, on the use of implemented technologies to concentrate on network activities. After elimination of elements suggesting the necessity of referring to business and sales, in compilation with Perechuda's definition, the definition derived from those given by Olejczyk and by Grudzewski and Hejduk is best suited to work on the concept of university virtualization. In this paper, we propose our definition of university virtualization, clearly indicating two stages, as follows:

A virtual organization is created through the increasing use of information and communication technologies in its activities, based on computer networks and the possibility of using internet information banks. By transferring a significant part of its activity to the internet, a virtual organization starts to operate in a networked way. Depending on the degree of virtualization, it can also conduct activities in the traditional (real) space apart from functioning on the internet (virtual) space.

Hence, virtualization of the university at an early stage is the transfer of activities to the internet space through the increasingly intensive exploitation of information and communication

technologies based on computer networks, and the possibility of using electronic databases and internet information banks. Then, at a later stage, after the implementation of available technologies, a sufficiently large part of activities is transferred to the digital space. Activities are organized virtually, e.g., in the educational sphere of inter-faculty and inter-university studies, in the administrative sphere of common inter-university units such as a libraries, dormitories, and in the research sphere of participation in joint scientific projects or establishment of consortia.

In the proposed definition, being active in the online space is an indispensable component of a virtual organization at any level of virtualization, but reaching higher levels also requires virtual organization of all activities – technology alone is not sufficient. This definition does not close the possibility of conducting activities in real space and it allows for a gradation of virtuality depending on the mutual distribution of activities: the relatively larger part of the organization's activities takes place in the virtual space and the more activities are organized virtual , the more virtual the organization is. Adopting such an approach, it can be said that currently there are no organizations that are 100% virtual, also in the context of cooperation between universities or other research institutions, as due to legal and formal restrictions, they must have basic elements for activities in the traditional space (an example here is the headquarters – an address that cannot be just an internet address). Virtualization should be understood as a transition from a traditional organization to an increasingly virtual organization.

The second chapter presents the legal conditions for the functioning of universities, pointing particularly to the elements that may be barriers to the process of virtualization or factors conducive to this process. This chapter refers to the concept proposed by Leja [2019] distinguishing four periods in the recent history of higher education in Poland:

- Period of relative certainty – until the end of the 1980s,
- The period of increasing uncertainty – 1990-2000,
- Period of uncertainty – 2000-2005,
- A period when uncertainty is a constant element of the game – since 2005.

There are also presented the most important elements of Act of 20 July 2018 – Law on Higher Education and Science, Journal of Laws 2018 item 1668 with later changes. The analysis of the Act shows two basic groups of tasks for universities:

- related to education, students, doctoral students, employees,
- related to research activities, knowledge transfer and popularization of science.

The set of goals for universities in this way allow to initially outline two spheres of university activity:

- didactic/educational sphere (related to education),
- sphere of scientific research.

In the dissertation, both of these spheres together with the third – administrative sphere – were included in the construction of the UVIM model.

The third chapter is devoted to the issue of university virtualization with the specificity of virtualization in particular areas of university activity: the area of didactics, the area of scientific and research activity, and the area of administration. For virtualization in the area of didactics, the issue of e-learning as the basic tool for virtualization of the didactic sphere has been discussed.

For virtualization in the field of scientific research, portals containing databases of articles, tools for bibliometric analysis supporting scientists in their work have been presented. For virtualization in the sphere of administration, the most popular tools have been presented that allow to prepare, among others, via the network:

- college recruitment,
- electronic student ID cards,
- didactic offer plan,
- electronic archiving of diploma theses,
- payments for educational services or dormitories,
- apprenticeships of students,
- surveys,
- reporting,
- employee matters (employment, salary calculation, etc.),
- university archive.

The fourth chapter presents the issue of maturity models, discusses the characteristic features of these models, the history of their creation as well as methods of classification and application. The notion of maturity can be defined as "the state of being complete, perfect or ready" [Lahrmann et al., 2010]. Kania [2013] points out that maturity develops gradually because of a process during which the desired features are shaped, enabling the performance of certain tasks. Hence, maturity is a state that can be graded from extreme immaturity to extreme maturity. However, to be able to determine the extent to which the phenomenon being assessed is mature, it must be possible to measure the maturity. This need was the beginning of the so-called maturity models.

From a formal point of view, the maturity model is a means of identifying the strengths and weaknesses of a certain field in an organization, consisting of several levels of maturity of the field used to evaluate the organization (or a part of it) and to map its development paths [Lahrmann et al., 2010]. It can also be said that "maturity models are used to describe, explain and assess the life

cycle of growth (...) and consist of a model and a questionnaire used to assess the level of maturity" [Hribar Rajterič, 2010] or "maturity models may be understood as artifacts which serve to solve the problems of determining a company's status quo of its capabilities and deriving measures for improvement" [Becker et al., 2009].

Most often, maturity models are derived from the widely recognized and appreciated CMM (Capability Maturity Model), developed in 1991 for the software development process. On its basis, in 2001, an integrated model CMMI (Capability Maturity Model Integrated) has been created, focused on the assessment of process maturity [Kania, 2013]. In this model – as in all subsequent models from various domains – the research domain is assessed at one of the five (most common) levels of maturity.

The main purpose of using maturity models is to codify knowledge about what good processes or actions should look like, how to evaluate them (criteria) and how to improve them [Kania, 2013], as well as to obtain systematic guidelines and a clear way of assessing the implemented solutions [Mircea, 2012]. Maturity models can be broadly divided into [Kania, 2013]:

- descriptive – allowing to determine the level of maturity of an organization,
- prescriptive – describing the target state and allowing to determine how far an organization is from it,
- transition models – defining what steps an organization must take to move from the current state to the desired one.

As said, maturity models were initially created for process management and software development, but due to their usefulness and relatively high flexibility which make them easy to modify, they were quickly adopted in other areas of application e.g., Business Intelligence, big data, and many others. Also, in the case of university virtualization efforts, maturity models can be a useful tool for assessing the implemented solutions.

In the fifth chapter, the author's model of university's virtual maturity is presented. Charts of classification schemes in particular areas are presented. The formula for calculating UVIM is given. The possible UVIM values are analyzed in relation to the degree of virtualization of individual areas of activity.

When building the University Virtual Index of Maturity (UVIM) model, it was assumed that UVIM would have (like most of the known maturity models) five levels. However, when analyzing the three identified and distinguished spheres of university activity (teaching, administration, and scientific research) that make up UVIM, it was found that it is not possible (or very difficult) to distinguish so many levels in each of these spheres. Therefore, the number of levels in individual

spheres is different and corresponds to the number of differentiating factors. UVIM has been constructed in such a way that under no circumstances can one unequivocally determine the UVIM value based on the level in only one of the spheres. The same level value in a given sphere can correspond to different UVIM values depending on the configuration of the values in the other two spheres, as shown in the figures below. Only knowing the levels in all spheres allows one to calculate the UVIM. A special case is the maximum level of UVIM, because it is reached only when the values of all components of the levels in the considered spheres reach their maximum levels.

VIM– Virtual Maturity Index (expressed in integers from 0 to 4)

- Level 0 Virtual
- Level 1 Pre-Virtual
- Level 2 Partially virtual
- Level 3 Predominantly virtual
- Level 4 Virtual

General formula for VIM calculation:

$$VIM = \left[\left(\sum_{i=1}^{i_{max}} \left((x_i + 1) * \frac{5}{^{max}x_i + 1} \right) \right) div \ i_{max} \right] - 1$$

Where:

x_i is the value of the virtualization index for a given (i) sphere of activity

$^{max}x_i$ is the maximum possible value of the virtualization index for a given (i-th) sphere of activity

i_{max} is the number of considered spheres of activity

Extreme levels for the UVIM index and for the individual spheres under consideration are called: Avirtual and Virtual. Intermediate levels are named only for the UVIM index, and for individual spheres, intermediate levels are only numbered, as illustrated in Fig. 1. Such a solution has been adopted because the values of the indicators of individual spheres of activity are only an intermediate stage for calculating the UVIM.

Fig. 1. List of the main and component levels. Source: Own elaboration.

x1 - level of virtuality achieved in the area of didactics

(expressed by integers from 0 to 4) where:

0 - **Nonvirtual** level

- *Classes are held on campus only, i.e., in classrooms, laboratories, etc.*
- *The dominant form of contact between students and lecturers is direct contact, i.e., physical contact or by means of paper correspondence – e.g., leaving assignments at the department, in the Dean's Office or in special correspondence boxes (compartments); lecturers leave materials to be copied at the university's copy centers. Making course materials available online is an individual initiative of very few academic teachers*
- *The university does not provide online syllabuses for courses within bachelor's and master's degree programs*

1 - First intermediate level

- *Classes are held on campus only, i.e., in classrooms, laboratories, etc.*
- *All mid-semester and final examinations, level tests and competency tests take place at the university only, under supervised self-directed conditions*
- *Student-teacher contact, apart from the face-to-face, i.e., physical contact, is possible online*
- *Some student materials are posted online for download (e.g., on websites, by e-mail, or through a special platform)*

2 - Second intermediate level

- *The university has a distance learning platform with an online examination system, but all the tests and final examinations take place at the university*
- *The courses take place mainly on campus, but there are also blended learning modes available*
- *Own material prepared by the university is posted for download on the internet*
- *Online consultations and group works are organized*

3- Third intermediate level

- *The university has a remote learning platform with an online examination system and some final exams, assessment and level tests are done remotely*
- *The courses of bachelor's, master's and doctor's programs are delivered in different modes: on-campus, blended learning, or e-learning*
- *Postgraduate courses, all of which or part of which take place remotely, are organized*

4-Virtual level (maximum)

- *The university offers first, second- or third-degree courses (bachelor's/engineering, master's, doctor's) that are entirely delivered online*
- *Any course can be taken remotely by a student*
- *Staff and students have email boxes on the university domain*

$x2$- level of virtuality achieved in the area of administration

(expressed by integers from 0 to 3) where:

0 - **Nonvirtual** level

- *The university does not have a website or has it in a non-developed, static version*
- *The university does not use any social media*
- *Employees and students do not have email boxes on the university domain*
- *The university does not use systemic university IT solutions (individual computers, not connected to the university network, work in organizational units of the university)*
- *Only a paper-based workflow is in operation*
- *Recruitment based on documents submitted by the candidates*
- *One can sign up for classes with the teachers or at the Dean's Office*

1 - First intermediate level

- *The university has an extensive, dynamic website*

- *Students do not have email boxes in the university domain*
- *Individual departments, divisions or other units of the university have separate systems with data taken from paper documents and entered by the administrative staff*
- *Recruitment based on documents submitted by the candidates*
- *One can sign up for classes at the teachers' office or at the Dean's Office, but one can also contact the teachers via email*

2 - Second intermediate level

- *The university has an extensive, dynamic website from which various documents can be downloaded*
- *The university is active on social media*
- *Course books are paper-based but there is no documentation of a paper-based semester credit card*
- *Recruitment based on a computerized application system accessible via the internet*
- *Registration for classes via the university's IT system*

3 - **Virtual** level (maximum)

- *There is a university-wide integrated information system (USOS type)*
- *Students and employees can contact the university units by logging into the system dealing with all the matters remotely*
- *Circulation of documents is electronic (including no paper handbooks or coursework)*

x3- level of virtuality achieved in the research area (expressed by integers between 0 and 2) where:

0 - **Nonvirtual** level

- *The university library provides access to paper version of materials only*
- *Scientific publications with the university's affiliation are published in hard copy only*
- *Conferences organized by the university are held on campus only*

1 - Intermediate level

- *The university library provides mainly paper version of borrowed materials, but there is also a chance to use various subscribed specialist databases, access electronic version of journals, etc.*

- *The university's scientific publications (including the university's scientific journals) are published in similar proportions in both paper and electronic versions*
- *Part of the university library's collection is digitized (including books originally published in hard copy) and there is a chance to use it remotely, along with various subscribed specialist databases, electronic version of journals etc.*

2 - **Virtual** level (maximum)

- *All the university library's collections are digitized, and it is possible to use them remotely, along with various subscribed specialist databases, electronic version of journals etc.*
- *All research papers with university affiliation are available to staff and students remotely*
- *All academic publications can be accessed remotely*
- *All academic conferences organized by the university are online, or if they are held on campus, then remote participation is always an alternative*

The following below formula is an instance of the general formula presented earlier, considering that i_{max}- the number of spheres under consideration equal 3 for the constructed model.

UVIM– Virtual Index of Maturity of the university (expressed as an integer from 0 to 4)

$$\boldsymbol{UVIM} = \left[\left(\sum_{i=1}^{3}\left((x_i + 1) * \frac{5}{{}^{max}x_i + 1}\right)\right) div \, 3\right] - 1$$

Where (as before):

x_i - The number of component levels in the spheres under consideration

${}^{max}x_i$- The number of maximum component levels in the spheres under consideration

Fig. 2. Possible configurations of the component levels in relation to increasing VIM values. Source: Own elaboration.

Classification Scheme Card for the State of Virtualization of Universities in the Sphere of Didactics

Classes are held on campus **only**, i.e., in classrooms, laboratories. No distance learning platform.

YES → Contact between students and teachers takes place directly **only**, i.e., physically, or via paper correspondence, e.g., leaving assignments in the department, in the Dean's Office or in special correspondence boxes (compartments); teachers leave materials to be copied in the university's copy centers. → YES → **0**

NO → Making course materials available online is **an individual initiative of** individual academic teachers, not an activity of the university units. The university does not provide online access to course syllabuses for courses within bachelor's, and master's degree programs. → YES → **0**

NO → The contact between students and lecturers, apart from the direct, i.e., physical contact, is also possible online. As part of the **activities organized by the units of the university,** materials for classes are made available to students online (e.g., on websites or by e-mail). → YES → **1**

NO → The university provides **syllabuses of** courses via the internet. → YES → **1**

NO → **There is a distance learning platform** at the university and materials are uploaded to it, but all mid-semester and final exams, level/competency/assessment tests **take place at the university only,** in a supervised self-directed environment. → YES → **1**

NO → **Only** some **mid-semester** assessment tests and level and competency tests take place **remotely** via the university's distance learning platform, but all **final** assessment tests and examinations **take place at the university only,** under supervised conditions. → YES → **2**

NO → **Some final** examinations, credit tests and exams **take place remotely** via the university's distance learning platform. At the university there are courses of the first, second or third degree (bachelor's, engineering, master's, doctor's), which are partially available via the internet. **Only postgraduate courses take place entirely via the** internet. → YES → **3**

NO → **Studies of first, second and third degree** (bachelor's, engineering, master's, doctor's degree) may take place partially or entirely via the internet. → YES → **4**
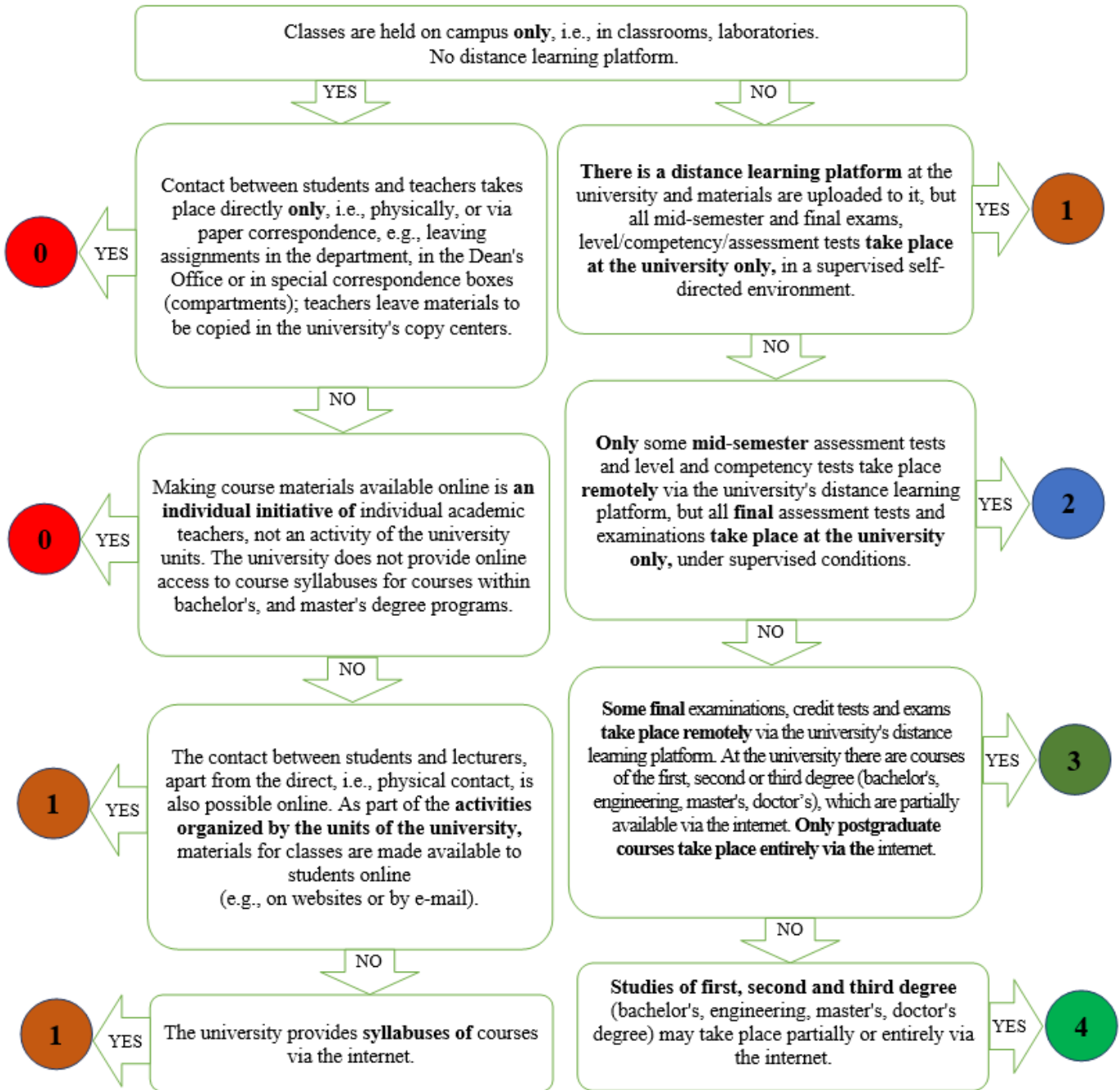
Fig. 3. Classification scheme in the sphere of didactics. Source: Own elaboration.
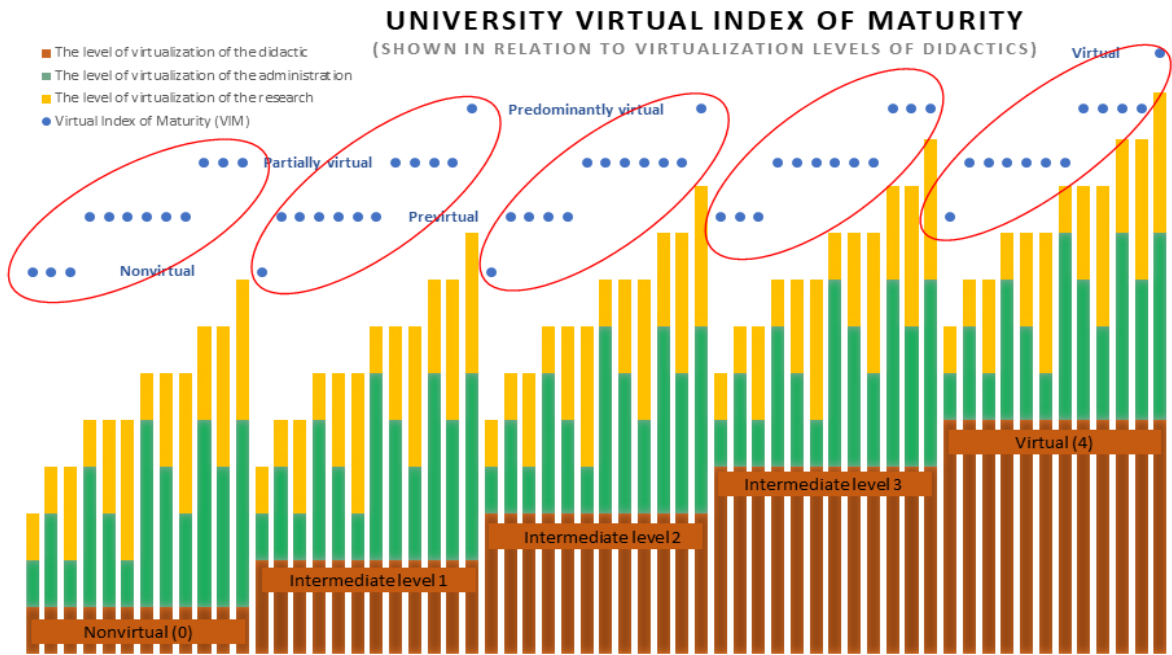
Fig. 4. Possible VIM levels in relation to increasing values of the didactics sphere level. Configurations of other component levels. Source: Own elaboration.
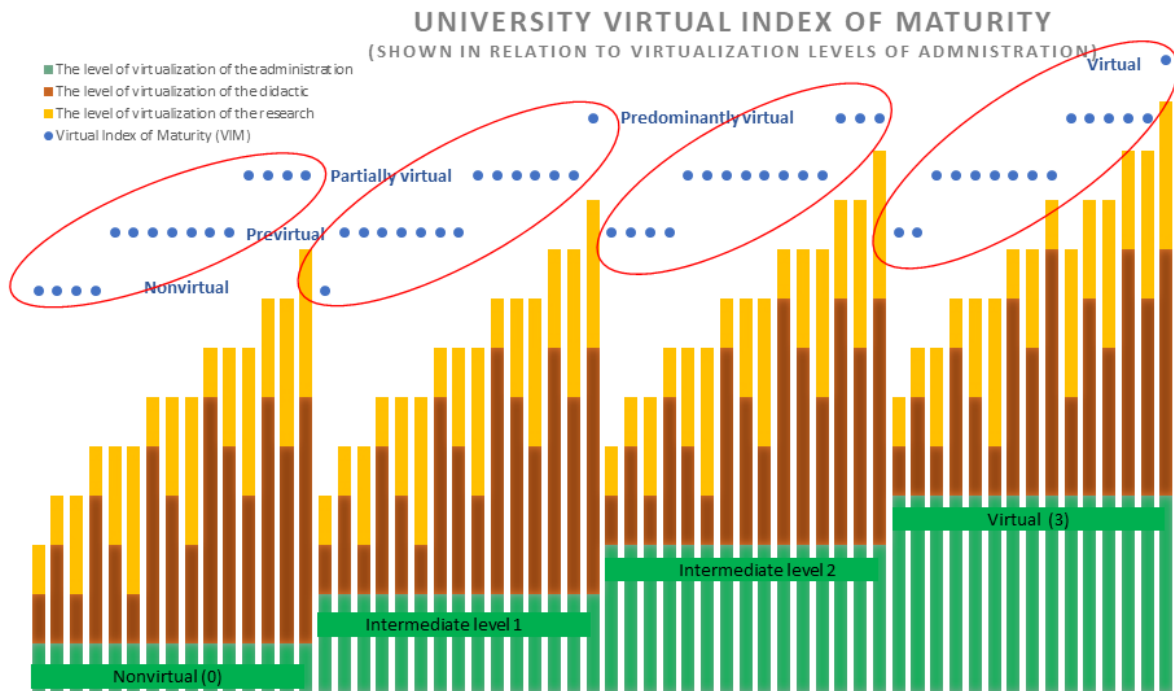

Fig. 5. Possible VIM levels in relation to increasing values of the administration sphere level. Configurations of other component levels. Source: Own elaboration.

Classification Scheme Card for the State of Virtualization of Universities in the Sphere of Administration

The university has a website. — NO → 0

YES

The relevant divisions and organizational units have their computers connected to local networks. — NO → 0

YES

Recruitment is based on a computerised system for applicants accessible via the internet. — NO → 1

YES

Registration for classes via the university's IT system. — NO → 1

YES

There is an electronic student book (no paper student book). — NO → 2

YES

There is a university-wide integrated information system with internet access (USOS type) covering all areas of administrative work. Students and employees logging into the system can contact the university units dealing with issues remotely. Circulation of documents takes place online, electronic signature is used. — NO → 2
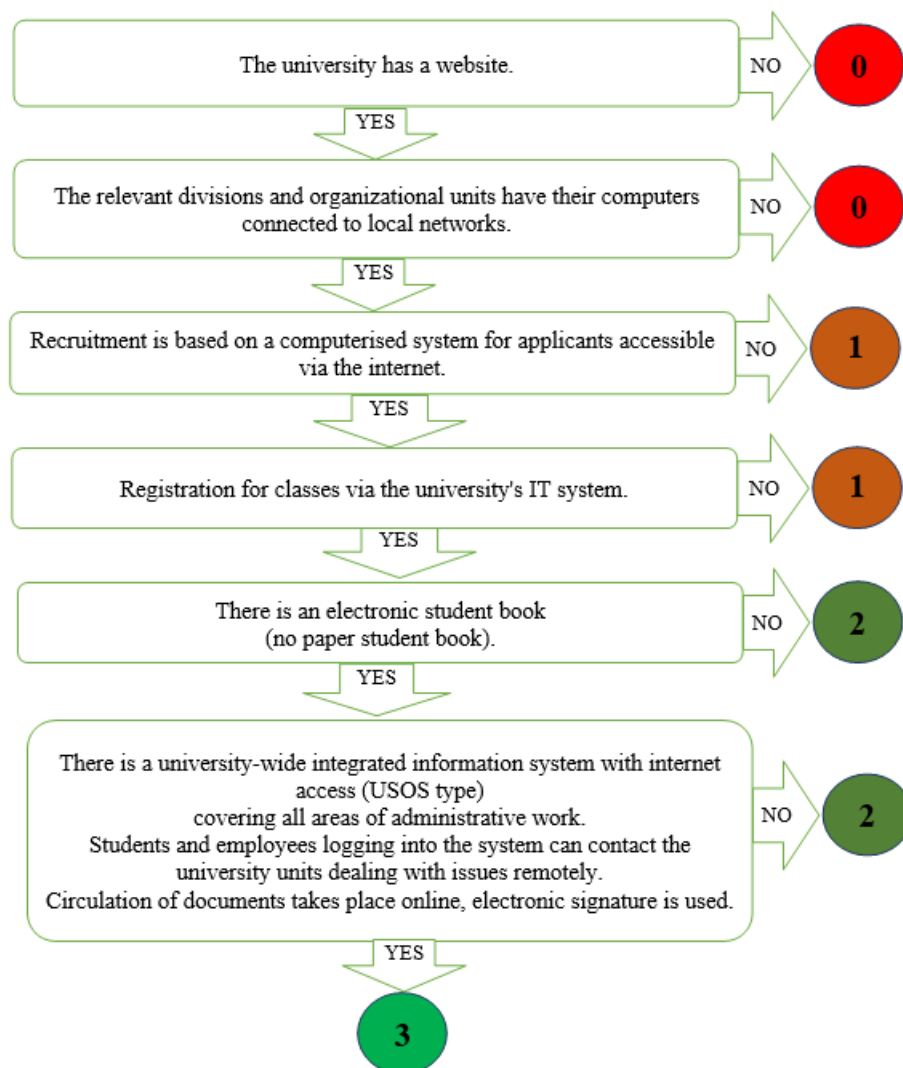
YES

3

Fig. 6. Classification scheme in the sphere of administration. Source: Own elaboration.

Classification Scheme Card for the State of Virtualization of Universities in the Sphere of Research

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┌────────────────────────────────────────────────────┐
│ All the university library's collections are in     │      ┌─────┐
│ paper version only, there is no possibility to use   │ YES  │  0  │
│ remotely purchased specialist databases, electronic  │─────▷│(red)│
│ version of journals, etc.                            │      └─────┘
└────────────────────────────────────────────────────┘
                       │ NO
                       ▼
┌────────────────────────────────────────────────────┐
│ Conferences organised by the university take place   │ YES  │  0  │
│ on campus only.                                      │─────▷│(red)│
└────────────────────────────────────────────────────┘
                       │ NO
                       ▼
┌────────────────────────────────────────────────────┐
│ Scientific publications of the university are        │ YES  │  0  │
│ published in hard copies only.                       │─────▷│(red)│
└────────────────────────────────────────────────────┘
                       │ NO
                       ▼
┌────────────────────────────────────────────────────┐
│ The university is a member of association of         │ NO   │  0  │
│ universities or has a research center or scientific  │─────▷│(red)│
│ information center or laboratory center etc. shared  │
│ with another university.                             │
└────────────────────────────────────────────────────┘
                       │ YES
                       ▼
┌────────────────────────────────────────────────────┐
│ All of the university library's collections are      │ NO   │  1  │
│ digitised and can be used remotely, along with       │─────▷│(brn)│
│ various specialised databases, electronic version    │
│ of journals etc.                                     │
└────────────────────────────────────────────────────┘
                       │ YES
                       ▼
┌────────────────────────────────────────────────────┐
│ All academic conferences organised by the university │ NO   │  1  │
│ are available online, or if they take place on       │─────▷│(brn)│
│ campus then remote participation is always an        │
│ alternative.                                         │
└────────────────────────────────────────────────────┘
                       │ YES
                       ▼
┌────────────────────────────────────────────────────┐
│ All scientific publications of the university        │ NO   │  1  │
│ can be accessed remotely.                            │─────▷│(brn)│
└────────────────────────────────────────────────────┘
                       │ YES
                       ▼
┌────────────────────────────────────────────────────┐
│ The scientific output of all university employees is │ NO   │  1  │
│ catalogued in an electronic database and can be      │─────▷│(brn)│
│ accessed remotely.                                   │
└────────────────────────────────────────────────────┘
                       │ YES
                       ▼
                    ┌─────┐
                    │  2  │
                    │(grn)│
                    └─────┘
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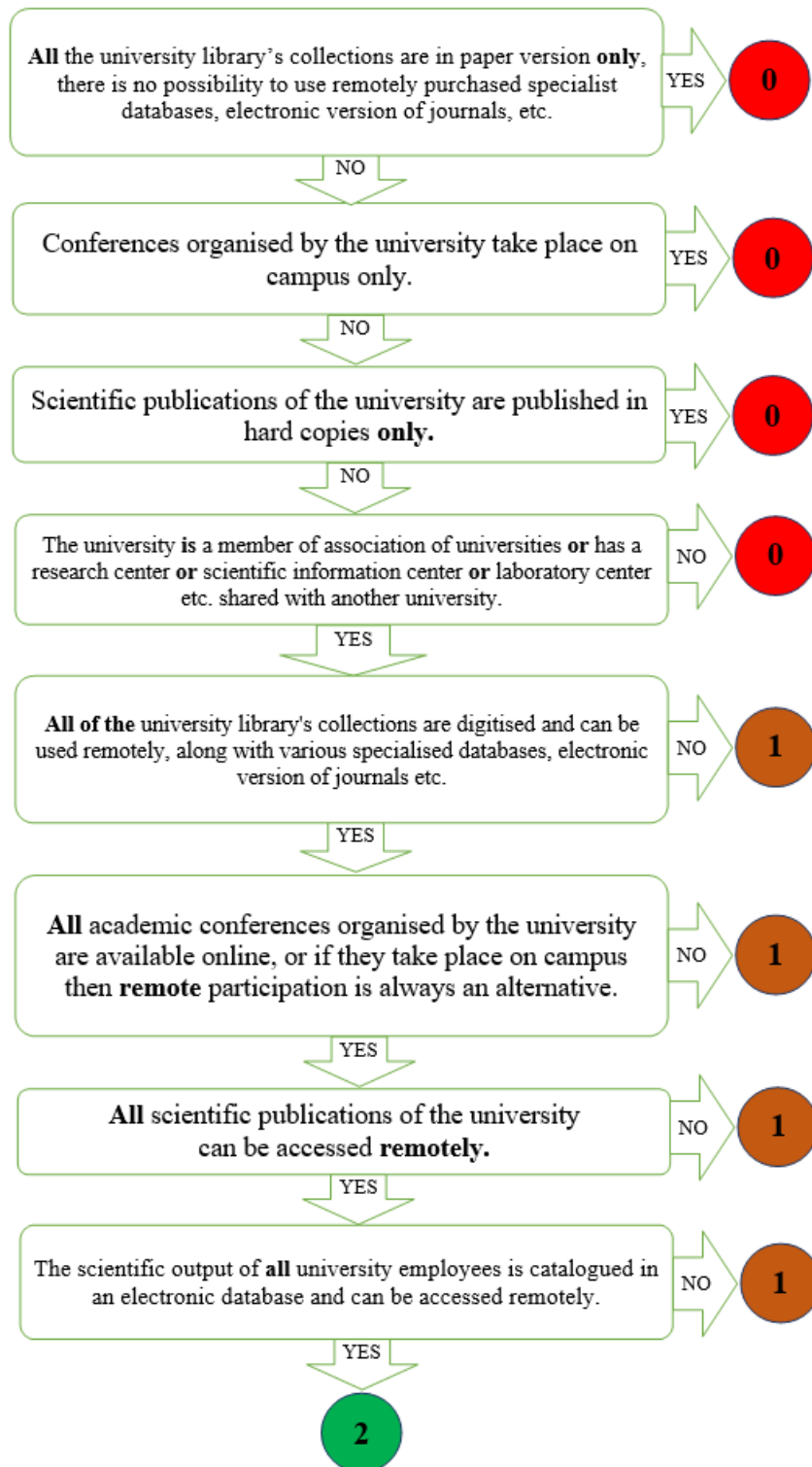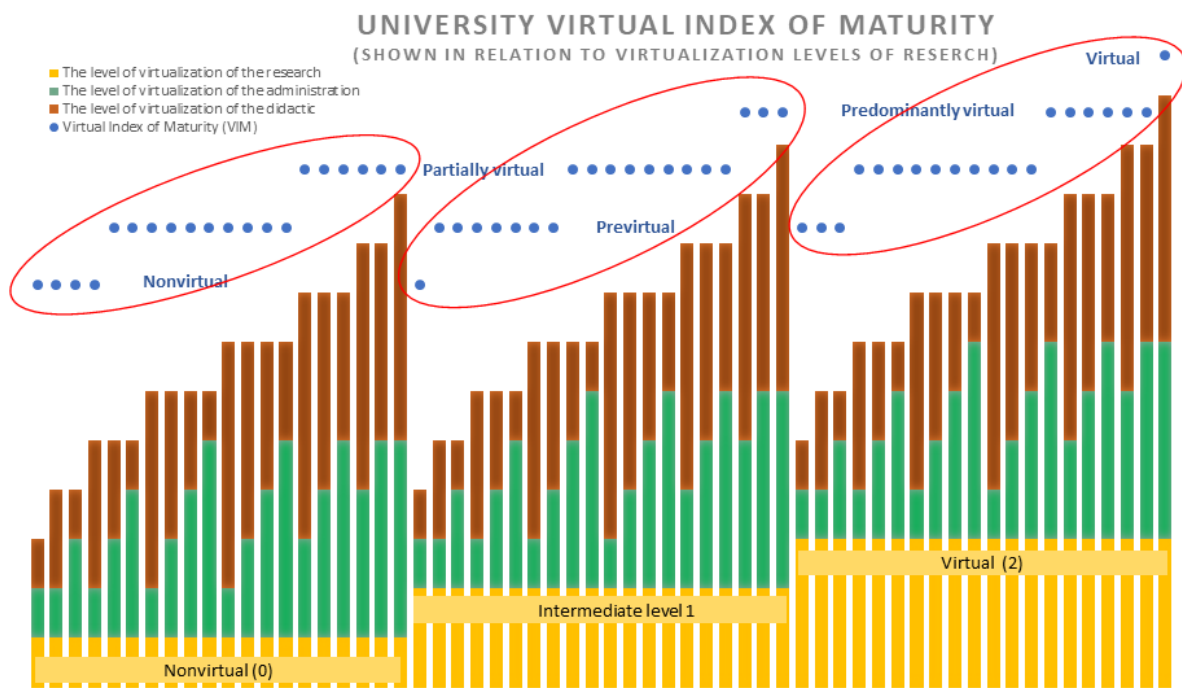
Fig. 7. Classification scheme in the sphere of research. Source: Own elaboration.

Fig. 8. Possible VIM levels in relation to increasing values of the research sphere level. Configurations of other component levels. Source: Own elaboration.

The model proposed in the dissertation is a comprehensive solution. With the help of cards containing classification schemes, it allows to determine the values of virtualization levels for individual identified spheres of university activity, thanks to which, in turn, it is possible to calculate UVIM. If there is a need to modify the model during the empirical applications, it is possible, as mentioned before, in a simple way because the model is flexible and scalable.

Chapter six presents the results of the focus group study conducted on May 17, 2022. This focus group study gave a positive verification of the proposed model and allowed to proceed to the case studies of selected universities, which is described in the next chapter.

Chapter seven presents case studies of selected universities. Each university is analyzed according to a uniform scheme: the university is presented (name, address details); lists of faculties, scientific discipline councils, scientific field councils existing at the university are provided; the website is presented (in the form of a screenshot) as one of the most important elements of functioning in cyberspace; the overall UVIM index for the university is calculated in accordance with the formula with the result of the assessment of individual spheres of activity shown using of classification schemes; according to the current state; then the entire business card

of the university from the database of the Academic E-learning Association (SEA) is quoted, next the value of the UVIM index is calculated for 2010 (time of the business card in the SEA database).

Thanks to the content of the SEA database, it was possible to assess the level of virtualization of universities included in the database in 2010. This allowed for a comparison of the situation at individual universities over the twelve years in all three separate spheres and in total in the UVIM value. This is shown in Charts 1, 2, and 3 below.
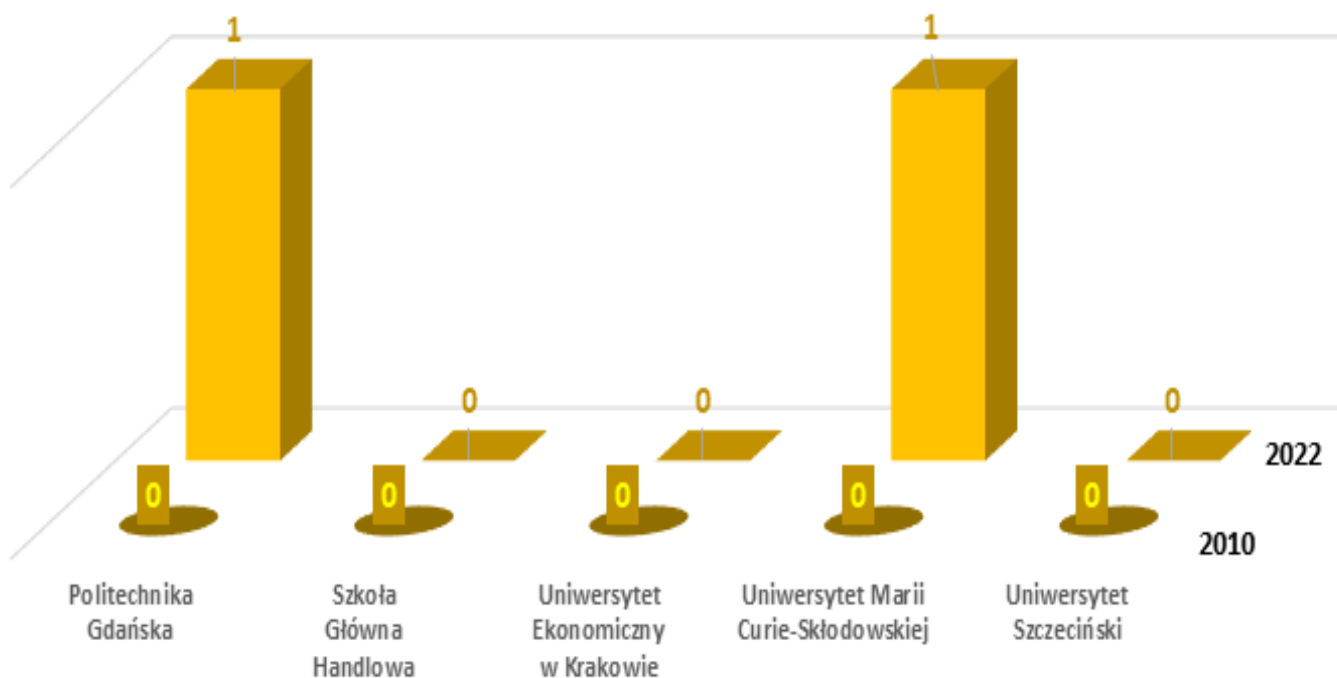
Chart 1. Values of the research virtualization subindex
of surveyed universities in 2010 and in 2022 Source: Own study
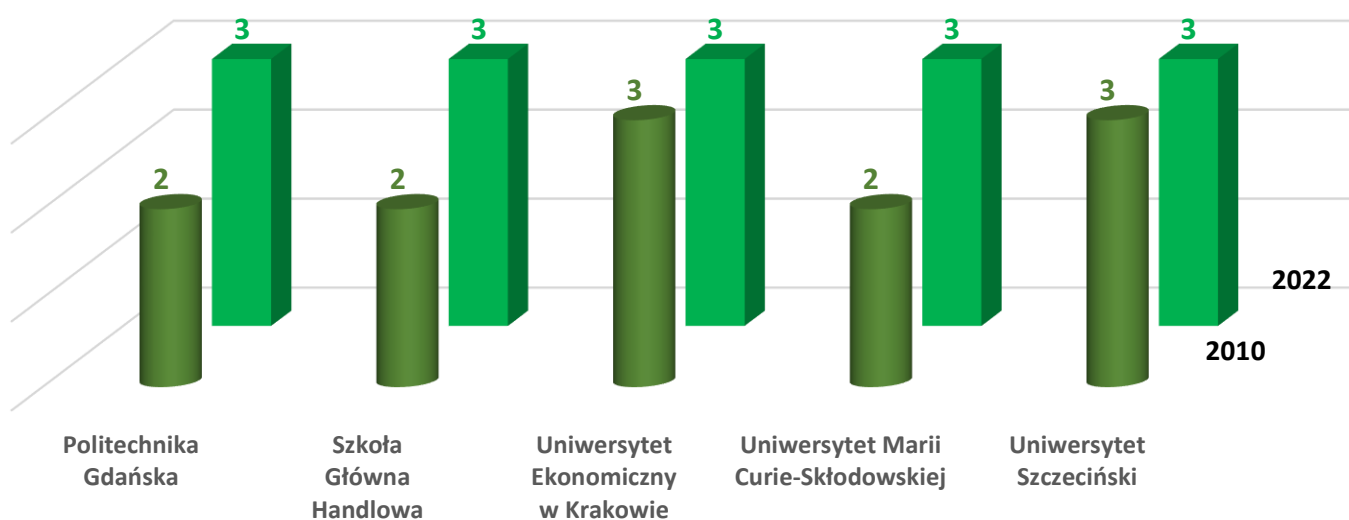
Chart 2. List of values of the administration virtualization subindex of the surveyed universities in 2010 and in 2022 Source: Own study

| | Politechnika Gdańska | Szkoła Główna Handlowa | Uniwersytet Ekonomiczny w Krakowie | Uniwersytet Marii Curie-Skłodowskiej | Uniwersytet Szczeciński |
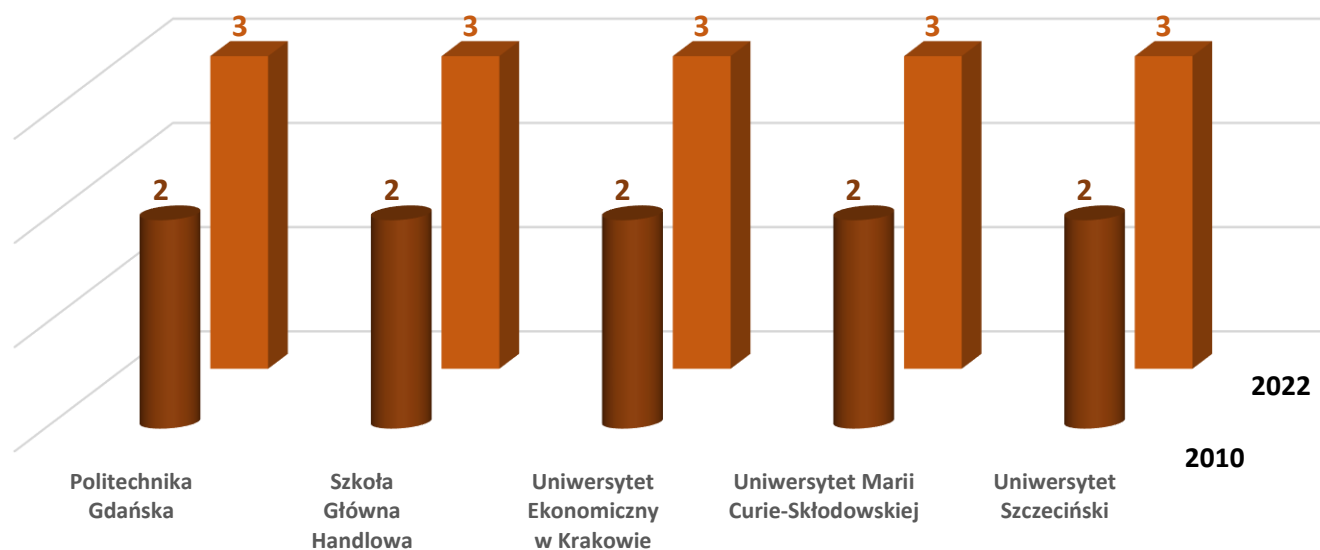
Chart 3. Values of the didactics virtualization subindex
of surveyed universities in 2010 and in 2022 Source: Own study

The most uniform progress was made at all the surveyed universities in the field of didactics: the value of the sub-index in this field changed everywhere from 2 to 3 (Chart 3). One of the very likely factors that caused the progress of virtualization in the field of teaching regardless of the university was the period of the pandemic, when there was a sudden need to develop university remote learning platforms, the need to develop methods of passing classes and passing exams without the need for students to appear at the university. On the other hand, one of the common barriers to achieving an even higher coefficient of the sub-index in this sphere are the legal restrictions.

A similar situation regarding the current level of the sub-index value can be seen in the sphere of administration. All the surveyed universities achieved the value of the indicator equal to 3 in this field. However, contrary to the description, in the didactic sphere, the progress at individual universities is different (Chart 2). In the majority (i.e., in the three surveyed universities: PG, SGH, UMCS) there was an increase by one, but in two (UEK, USZ) the current level has been maintained since 2010.
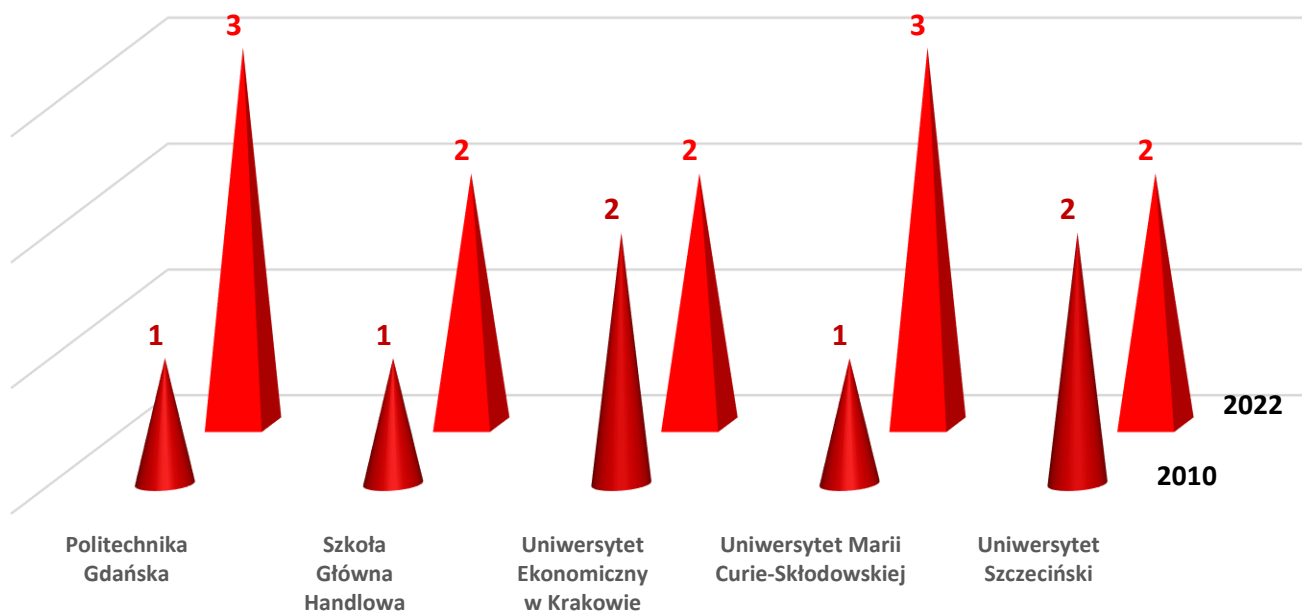
Chart 4. UVIM values of the surveyed universities in 2010 and 2022 Source: Own study.

Considering the changes in the field of scientific research, it can be seen that significant progress has been made at two of the surveyed universities: PG and UMCS. This success was influenced by formalized forms of inter-university cooperation in the form of the Inter-University Scientific Research Center "Filioque" established jointly by the University of Rzeszów and UMCS in Lublin and the Inter-University Laboratory of Nuclear Magnetic Resonance (NMR), the Inter-University Laboratory of Biotechnology and the inter-university field of study Construction Chemistry of the Gdańsk University of Technology.
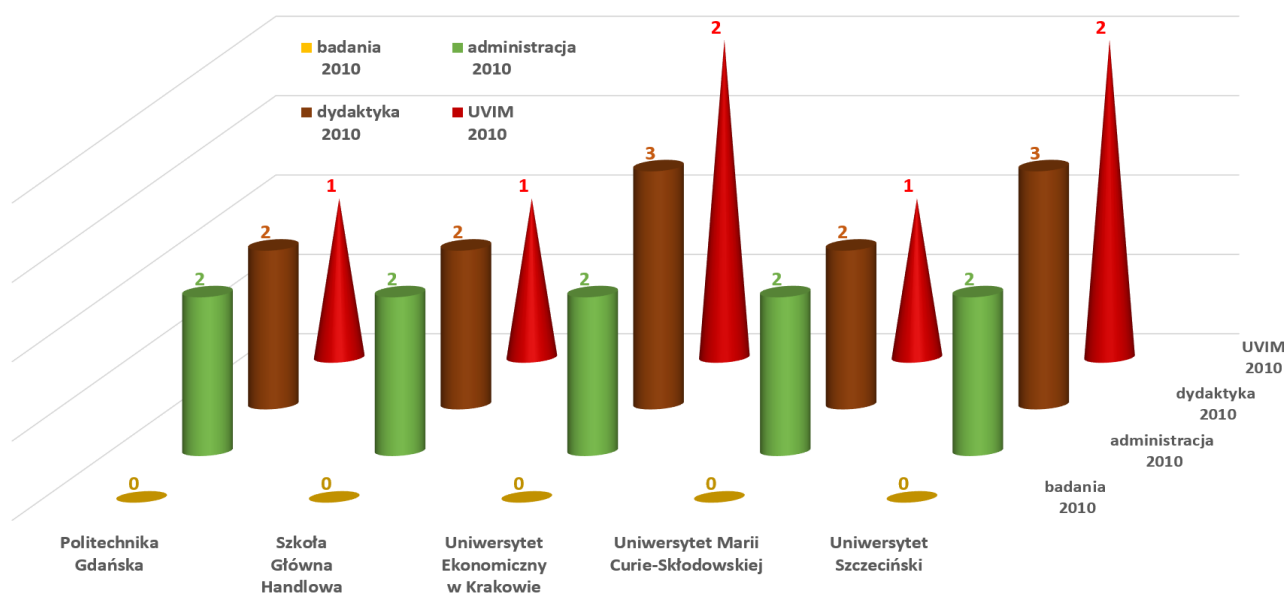
Chart 6. List of subindices and UVIM values for the surveyed universities in 2022

Source: Own study

Considering the overall assessment of virtualization using UVIM (see Charts 4 - 6), it can be seen that the greatest progress has been made in the case of UMCS and Gdańsk University of Technology, there was an increase by two levels. The Warsaw School of Economics raised its UVIM by 1, the other two USZ and UEK universities, despite the increase in the subindex in the didactic sphere, maintained their UVIM at the level of 2.

The entire dissertation ends with a summary, where the hypothesis is summarized with the results obtained. In addition, the encountered difficulties and obstacles that may be the basis for further research or additional verification of the results were indicated.

This thesis is an attempt to take a broad look at the phenomenon of university virtualization in a holistic way, covering all its aspects.

The hypothesis formulated in the introduction to this thesis:
"It is possible to create a virtual university maturity model, serving as a tool to assess the current state of virtualization of a university."
has been confirmed, and the main goal of the work set out in the introduction:
"based on the identification of areas, stages and conditions of virtualization of a university in the network – development, implementation and testing of a university's virtual maturity model on

selected case studies"

has been achieved. The model with the UVIM index proposed in the dissertation is a broad and comprehensive tool for evaluating the virtual maturity of a university. It allows for the assessment of each area of activity: teaching, research, and administration, considering its specificity. As a result, general information about the maturity of the university in the context of virtualization and networking activities is obtained. Proposing this tool is both a theoretical and practical contribution to research in the field of virtualization of universities.

The need for online presence and cooperation through networks has already been noticed by educational institutions, including universities. However, research on the issues of network and virtualization maturity as a whole has not yet been published. Existing models ([Secundo et al., 2016; Sherstobitova et al., 2021]) evaluate one of the spheres of university activity and may be considered incomplete because they do not measure virtualization maturity in all three areas: teaching, research, and administration. The index proposes in the dissertation combines everything into one coherent model dedicated to all areas of the university's activity. In this way, the University Virtual Index of Maturity (UVIM) extends the existing research on virtualization maturity and embeds it in the context of higher education.

One of the limitations of the model, especially in the case of research conducted on external universities, is the possible difficulty in reaching all the necessary information needed to classify and determine the level of virtualization. Since transparency and openness are one of the elements of networking and virtuality, in order to overcome this limitation, it can be assumed that the lack of access to information lowers the value of UVIM.

The use of the proposed model should lead to the development of best practices and guidelines for higher education managers, researchers and other stakeholders dealing with virtualization issues.

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