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Structure of Competences of Lublin University of Technology Students in the Field of Sustainable Development

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Abstarct:

Purpose: *The aim of the study is to define the structure of competences of students at the Lublin University of Technology (LUT), Poland, in the field of sustainable development.*
Design/Methodology/Approach: *The research method is a diagnostic survey, and the tool is a self-assessment questionnaire. The conceptualization of sustainable development competences adopted in the study is the ability to shape future scenarios through active participation in modeling and transforming society towards sustainable practices. The eight competences of de Haan were adopted as research frames. Students of managerial and technical faculties were surveyed.*
Findings: *The structure of the competences examined is partially different from that presented in the literature. Factor analysis indicates two broad groups of competences - multidimensional approach to problems and reflexivity. The structures of competences in separate groups differ from each other. In the managerial group there is a critical perception of oneself and the world and a multidimensional approach to problems, while in the group of students of technical faculties – a cooperative and multidimensional approach to problems, as well as contesting and forecasting. Moreover, some students from the management group (marketing and market communication) and students of technical faculties differ in terms of cooperation competences.*
Practical Implications: *The results of the study enable the introduction of content and methods into the study curricula to increase competences in the field of sustainable development.*
Originality/Value: *The contribution is the research-based indication that students of different fields of study within one university have a different competence structure in the field of sustainable development.*

Keywords: *Competences, sustainable development, students at the Lublin University of Technology.*

JEL codes: *Q56, M14, O15.*

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1. Introduction

For over two decades, we have witnessed the increasingly important role that education plays in transforming today's society into a more sustainable one (bibb.de, 2005). This was reflected in such programs as the Decade of Education for Sustainable Development (bibb.de, 2005) and the 2030 Agenda of 17 goals for sustainable development (unic.un.org.pl, 2015). In the light of these documents, higher education is the main addressee of the challenges facing the global community in the field of sustainable development (SD). Higher education's attribution of this role stems from its key function of generating and imparting knowledge through research and teaching (bibb.de, 2005). Given that universities are one of the main centers of education, incorporating the principles of sustainable development into their curricula can provide students with knowledge and skills about the changes, systems and requirements of the new business paradigm (Setó-Pamies and Papaoikonomou, 2016).

According to SD scientists, to fulfill this role in the field of education, there must be a change in the teaching paradigm. It should be an epistemological change leading to a balance based on holism, subjectivity and systemic thinking (Sterling, 2004). The difficulty with paradigm shifting is that it must be disseminated and implemented throughout the entire university system (Lozano *et al.*, 2013). The implementation of education for sustainable development (ESD) is such a challenge that it is necessary to reorient curricula and educational models towards perceiving students as engaged actors in the society.

The provision of ESD by universities aims to promote the development of competences that enable students to reflect on their own actions, considering their social, economic, environmental, and cultural effects, both present and future, and to assess them from a local and global perspective with the ultimate goal of promoting sustainable societies (Rieckmann, 2017). For social transformation to be sustainable, education should be creative, innovative, constructive, culturally appropriate, and action-oriented (Tilbury and Wortman, 2004).

The importance of ESD prompted the authors to undertake research among students at the Lublin University of Technology. The aim of the research was to diagnose the structure of competences in the field of sustainable development, with particular emphasis on the type of studies as a variable differentiating the structure of competences. Research questions focus on the issue of assessing the level of competences possessed by students, which will help both teachers and students to develop them. These questions were formulated as follows:

1. What is the structure of LUT students' competences in the field of sustainable development?
2. Does the structure of competences in the field of sustainable development differ depending on the type of studies (managerial / technical)?

2. Characteristics of Competences in the Field of Sustainable Development

For many years, competences in sustainable development have been defined in a variety of contexts, offering the full set of knowledge, skills, values and attitudes needed to ensure that today's students and future leaders are prepared to solve complex sustainability problems and achieve a sustainable future (Lambrechts *et al.*, 2013). Despite the discrepancies in the definition of competences and the confusion related to the use of the term, there is a need to define competences for sustainable development to support the development of ESD curricula (Wiek, Withycombe, and Redman, 2011). Barth *et al.* (2007) addresses this need by defining competences in the context of sustainable development as the ability to shape future scenarios through active participation in modeling and transforming society towards sustainable practices. Competences in the field of SD are presented in literature as groups, and one of the most cited is the concept of de Haan's Gestaltungskompetenz (2006). According to de Haan (2010), the elements of sustainability competences are:

- Competence to think in a forward-looking manner, to deal with uncertainty, predictions, expectations, and plans for the future;
- Competence to work in an interdisciplinary manner;
- Competence to achieve open-minded perception, transcultural understanding and cooperation;
- Participatory competence;
- Planning and implementation competence;
- Ability to feel empathy, sympathy and solidarity;
- Competence to motivate oneself and others;
- Competence to reflect in a distanced manner on individual and cultural concepts.

Developing these competences among students is of particular importance for the development of their SD skills (Stibbe, 2009). Acquiring these competences allows students to become agents of positive change in the workplace and personal life (Sipos, Battisti, and Grimm, 2008). Previous studies on the evaluation of ESD have focused on the competences of students (Cebrián and Junyent, 2015; Wiek, Withycombe, and Redman, 2011). The conclusions from these studies indicated the need for further empirical research on competences in the field of SD. This article is part of the fulfillment of this need as it describes competences in the field of sustainable development, reviews the literature on the assessment of competences in the field of SD, and presents the results of competency self-assessment studies carried out among LUT students.

3. Characteristics of Tools for Assessing Students' SD Competences

A review of articles examining competences, skills or learning outcomes reveals a picture of a variety of research methods, contexts, thematic areas, and tools. An overview of the research tools used so far is presented in Table 1.

Table 1. *Tools used to assess the competences of students in the field of SD*

Authors	Research Tool
Nikel (2007)	Questionnaires, narrative tasks and an interview to test the perception of ESD competences
Segalàs, Ferrer-Balas and Mulder (2008; 2010)	A 5-year research project to analyze how sustainability competences were introduced into the curricula of technology universities. Concept maps served as tools for assessing competence in the field of sustainable development.
Hegarty *et al*. (2011)	Critical article analysis, ecological footprint calculator and student learning outcomes analysis in a self-paced sustainability course
Habron, Goralnik and Thorp (2012)	Assessment of systemic thinking skills of undergraduate students through a short answer exam, assessment of interactive dialogue in small groups online, homework assignments, creating an online community engagement tutorial, and preparing a final reflection project (in a group or individually)
Cebrián and Junyent (2015)	an open-ended questionnaire to test students' perceptions of ESD competences
Rose, Ryan and Desha (2015)	'before and after' questionnaires to assess learning outcomes as a result of an attempt to renew the curriculum by integrating sustainability into the first year of engineering studies
Shephard *et al*. (2015)	statistical model with repeated measurements of longitudinal mixed effects to assess the development of sustainable development-related affective effects
Pretorius, Lombardand Khotoo (2016)	Evidence-based reflection presenting a narrative assessment of the experience gained through study in two undergraduate sustainability-oriented modules at the University of South Africa
Mercer *et al*. (2017)	designing educational games to support student design thinking and communication skills, and assessing student development through questionnaires and qualitative feedback
Warr *et al.* (2017)	A 3-year project, under which an interdisciplinary place-based learning initiative on SD principles was designed, implemented and evaluated. The aim was to assess the impact of this approach on sustainable development, both in terms of operational outcomes and learning outcomes, and to make recommendations for the continuation of place-oriented learning initiatives within the academic integration agenda for SD.
García, Junyent and Fonolleda (2017)	instruction enabling the assessment of professional competences in ESD
Sandri, Holdsworth and Thomas (2018)	an assessment tool, based on a draft scenario / vignette question, to collect information on the sustainability competences of university graduates that can be used in comparative research at different universities

Source: *Own study.*

According to the literature review, various research tools are used to assess competences and learning outcomes. Although the use of multiple tools offers the opportunity to obtain a comprehensive overview of the development of competences in sustainable development, it also reflects the lack of a common framework of SD competences and effective teaching and learning approaches that help to develop these competences (Sterling *et al.*, 2017). More in-depth research is needed to design and

validate instruments to assess and monitor student performance in terms of sustainable development (Barth and Rieckmann, 2018).

4. Materials and Methods

The competence assessment technique was used in the research. A specific variant of competence assessment is self-assessment, in which the source of information on the manifested level of competent action is the opinion of the respondents themselves. This method is very often used in human resource management in organizations. When making self-assessment, the person's task is to respond to specific statements.

The self-assessment questionnaire was chosen as the research tool. It was based on the model of 8 key competences for sustainable development (de Haan, 2006; 2010). These competences, for the sake of this research, have been shortly named as follows: cooperation, critical thinking, self-awareness, anticipation, problem solving, strategic thinking, systemic thinking, regulations. The questionnaire for self-assessment of competences in the field of SD consists of 40 statements (5 for each of the competences listed). The responses were rated as follows: (5) I fully agree, (4) I agree, (3) I am not sure, (2) I disagree and (1) I disagree completely. The questionnaire also included questions about gender and the field of study. The developed research tool has been created and pilot-tested prior to final implementation.

Undergraduate, engineering, and graduate students of LUT participated in the research. The type of studies – managerial or technical – has been adopted as the independent variable. Hence, the respondents were divided into two categories: students of managerial studies (management, marketing and market communication, management, and production engineering) and technical studies (logistics engineering, multimedia engineering, transport, construction and architecture).

The research was carried out using the MS Forms tool in the period from February 25, 2021, to March 24, 2021, on a group of 667 students of the LUT. Women constituted 57.7% of the respondents and men - 42.3%. In line with the adopted research objective, most of the respondents were students of management (73%, including students of management 38.9%, marketing and market communication 21.9% and management and production engineering 12.2%). Students of technical faculties constituted 26.7% of the respondents (0.3% - no data).

The respondents' answers to the questionnaire questions were entered into the computer. Based on those, created data was additionally aggregated, including answers to the questions concerning individual competences. The variables obtained in this way were named analogically to the theory-driven competences: cooperation, critical thinking, self-awareness, anticipation, problem solving, strategic thinking, systemic thinking, regulations. The Cronbach's alpha coefficient for the data from the respondents' answers is 0.85 and for aggregated data it is 0.79. The following statistical methods were used: factor analysis with the criterion of eigenvalue and

analysis of the scree chart as criteria for selecting the number of factors (in order to distinguish groups of questions creating competences in the field of sustainable development or to determine the structure of questions on the basis of which it was found which competences correspond to which group of questions), U Mann-Whitney test (comparison of mean values for ranks in two groups of students), Kruskal-Wallis test (checking whether the mean levels of the analyzed variables differ in the groups) and Dunn's post hoc test (finding which groups differ from each other in terms of the average level). Statistical analyzes were performed using the Statistica TIBCO package.

5. Empirical Results

The very first step included a factor analysis applied to check whether the structure of theoretically assumed competences is analogous to the empirical one. Following the analysis of the scree plot, 8 factors were distinguished and named as in Table 2.

Table 2. *Competences distinguished based on the factor analysis of the obtained data*

Factor	Questions
Factor 1 – systemic thinking	31, 32, 33
Factor 2 – co-operation	3, 4, 5
Factor 3 – readiness for change	16, 17
Factor 4 – nonconformity	6, 7, 8
Factor 5 – self-criticism	9, 10
Factor 6 – self-awareness	12, 13, 21, 26
Factor 7 – prolocal activity	27
Factor 8 – regulations	38, 39, 40

Source: *Own creation.*

The comparison of the theoretically distinguished structure of competences with the structure resulting from the conducted factor analysis shows similarities as well as some differences. There is significant similarity in the following competences: cooperation (factor 2), systemic thinking (factor 1) and regulations (factor 8). On the other hand, some items theoretically assigned to the critical thinking competence are part of two distinct factors, which can be defined as nonconformity (factor 4) and self-criticism (factor 5). The empirically distinguished factor 6 was defined as self-awareness. It consists of items assigned to competences defined theoretically as self-awareness (two items - 12, 13), problem solving (one item - 21) and strategic thinking (one item - 26).

The factor analysis was also performed with reference to aggregated data. The division (criterion of eigenvalue, analysis of the scree plot) into two factors explaining 53.5% of the variance variation was adopted. The factor loadings and the factors separated on their basis are presented in Table 3. Factor 1, including problem solving, strategic thinking and regulation, was defined as a multidimensional approach to problems. Factor 2, which comprises critical thinking, self-awareness, and anticipation, was

defined as reflectivity. The factor analysis was also conducted separately for the groups of students of managerial and technical faculties (Tables 4 and 5).

***Table 3**. Factor loadings after Varimax rotation (total respondents)*

Variable	Factor 1	Factor 2
cooperation	0.426	0.319
critical thinking	-0.039	0.845
self-awareness	0.381	0.591
foresight thinking	0.263	0.622
problem solving	0.791	0.123
strategic thinking	0.717	0.304
systemic thinking	0.476	0.490
regulation	0.780	0.084

***Source:** Own creation.*

***Table 4.** Varimax rotation factor loadings (management students)*

Variable	Factor 1	Factor 2
cooperation	0.451	0.264
critical thinking	0.818	-0.052
self-awareness	0.645	0.311
foresight thinking	0.588	0.236
problem solving	0.232	0.773
strategic thinking	0.394	0.683
systemic thinking	0.567	0.412
regulation	0.081	0.793

***Source:** Own creation.*

In the group of managerial students, the first of the distinguished factors consists of variable critical thinking and self-awareness, and the second is problem solving, strategic thinking and regulations. The number of extracted factors and the percentage of variance variation explained (53.2) are analogous to the results obtained from the factor analysis without division into groups, but their structure is partially different. The second factor distinguished in the managerial group is a multidimensional approach to problems (similarly to the group in general), while the first factor is partially different, i.e., it does not include the foresight thinking variable. This factor has been called critical perception of oneself and the world.

***Table 5.** Varimax rotation factor loadings (technical students)*

Variable	Factor 1	Factor 2
cooperation	0.615	0.134
critical thinking	-0.075	0.851
self-awareness	0.445	0.494
foresight thinking	0.286	0.698
problem solving	0.799	-0.011
strategic thinking	0.729	0.202
systemic thinking	0.507	0.406
regulation	0.784	0.203

***Source:** Own creation.*

The factor analysis in the group of students of technical faculties also made it possible to distinguish two factors explaining 55.3% of the variance. The first consists of the variables of cooperation, problem solving, strategic thinking and regulation, while the second - critical thinking and anticipation. The structure of the first factor is like the first factor in the group of respondents in general, however, it is extended by cooperation. It has been called a cooperative and multidimensional approach to problems. The second factor includes two of the three variables (without the competence of predicting) that make up the second factor for the total number of surveyed students and has been named contesting and forecasting.

As the empirically separated structure of competences in the field of sustainable development in the managerial group and in the group of students of technical faculties is different, it was decided to check the existence of differences in the eight competency groups (aggregated data). For this purpose, the Mann-Whitney U test was carried out, which showed a statistically significant difference between the group of managerial and technical students in terms of cooperation competences ($U = 37272.00$; $Z = 2.77$; $p = 0.006$). No differences were observed about the remaining competences.

The group of managerial students is diverse (students of management, marketing, and market communication as well as management and production engineering). Therefore, in-depth analyzes were carried out to compare competences in four groups (each of the fields of study defined as managerial and technical) using the Kruskal-Wallis test. A statistically significant result ($p = 0.0307$) was obtained regarding the competences of cooperation. This means that there is at least one group whose results differ statistically significantly from at least one of the others. To identify them, a post hoc Dunn test was carried out, which showed that the degree of possessing this competence differs in the group of students of marketing and market communication and students of technical faculties ($p = 0.0432$).

6. Discussion and Conclusions

The empirically verified structure of the examined competences is partially different from that presented in the literature and allows for the improvement of the tool designed for the purpose of this research. The factor structure distinguished on the basis of aggregated data indicates two broad groups of competences (multidimensional approach to problems and reflectivity).

The factor structures in groups distinguished according to the type of studies differ partially from the structure distinguished for the entire group as well as differ among themselves. The managerial group is characterized by a critical perception of oneself and the world and a multidimensional approach to problems. The group of technical faculty students is characterized by a cooperative and multidimensional approach to problems, as well as contesting and forecasting. Students of marketing and market

communication and students of technical faculties differ in terms of cooperation competences.

Research conducted among Spanish teachers indicates cooperation as the competence that is most developed in the education process (Poza-Vilches, López-Alcarria and Mazuecos-Ciarra, 2019). At the same time, a review of the results of empirical research (Cebrián *et al.*, 2019) shows the lack of clear evidence on the impact of education on the shaping of competences in the field of sustainable development. A similar conclusion can be drawn from the research conducted among LUT students. This is particularly evident in the management group, which pursues many subjects related to sustainable development in the program of studies.

This suggests the need to apply a new paradigm of teaching and learning approaches and strategies, such as project-based learning, learning by service and learning by doing (Bessant *et al.*, 2013; Thomas, 2009). Such activities should strengthen the competences or skills necessary to operate in accordance with the principles of sustainable development (Wals, 2010).

The review of the literature on the subject and the obtained research results indicate that it is necessary to constantly monitor the level and structure of competences in the field of sustainable development and to improve the methods of their measurement.

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