Circular Economy in the Higher Education System

Anatolii Melnychenko
PhD in Philosophy,
Professor,
Department of Theory and
Practice of Management,
National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute
Kyiv, Ukraine.
melnichenkot@ukr.net

Anna Pohrebniak
PhD in Economics,
Associate Professor,
Department of Economics and
Entrepreneurship,
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute
Kyiv, Ukraine.
anna.u.pogrebnyak@gmail.com

Olena Kostiunik
PhD in Economics,
Associate Professor,
Department of Economics and
Entrepreneurship,
National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute
Kyiv, Ukraine.
elena_kostynik@ukr.net

Tetiana Shchepina
PhD in Economics,
Associate Professor,
Department of Economics and Entrepreneurship,
National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute
Kyiv, Ukraine.
supertanuta@gmail.com

Denys Derevianko
PhD in Philosophy,
Senior Lecturer,
Department of Educational and
Socio-Cultural Management and Social,
Bohdan Khmelnytsky National University
at Cherkassy,
Cherkassy, Ukraine.
denisderevyanko28.04@gmail.com

Abstract

Urgency of the competence formation in the higher educationsystemto carry outactivities in circular economyis due to rapid changes in global economic and environmental contexts.Population growth in the world, rapid urbanization and depletion of natural resources require transition from traditional linear model of the economy to circular one, which is focused on closed cycles of resources's use. Therefore, there is a demand in the market for qualified specialists who can work with innovative technologies and implement sustainable development principles includingbothtechnical knowledge, and understanding of economic, environmental and social aspects of the circular economy. The goal of scientific work is to define principlesof the competences' formation in the higher educationsystemin thecircular economydevelopment for future specialists using the systemic approach methodology. In the research, authors singled out reasons for this formation of competences in the higher educationsystem in the circular economy and structural components of professional competences, which include theoretical-methodical, practice-oriented, cognitive-value components. Objective and subjective prerequisites for the competences' formation in the higher educationsystemin the circular economy are also outlined. Functional elements of students' competences for activities in the circular economy are defined, which include as follows: knowledge, applied, existential, and stimulating elements. Sequence of measures in terms of the education organizationto achieve its effectiveness by forming students' competencesto carry out activities in thecircular economy is proposed.Information-structural system for the competences' formation ineducation for activities of employees in thecircular economy as a recurring ratio is presented.

Keywords: Sustainable Development, Circular Economy, Higher Education, Competences, Educational Aspect,Pedagogical Aspect, Competences' Formation.

Introduction

To date, one of the most urgent directions of development of modern economic science is solving the problem of dysfunctionalization of

industrial forms by rganizing management systems, which are oriented to implement extensive economic practices, which fundamentally construct the target vector of the economic system development directed toaccelerated growth of efficiency parameters, objectively ignoring destructive external manifestations, which are expressed in destructive effects on external social-natural and ecological environment.

Sustainable development principlewas one of fundamental concepts that formed the road map of complex coordination and applied harmonization of the attempt of business agents to increase parameters of economic efficiency combined withqualitative integration of relevant causal relationships of economic activity and the state of social and ecological environment. Within economic science, wide range of additional theories and tools designed to implement relevant provisions of the triune model of interaction of economic, social and ecological aspects of social development has been developed. One of the most complex theories, in which practical mechanism to implement conceptual aspects of sustainability is offered, particularly in general greening of economic activity, is the circular economy theory.

The goal of this scientific work is to define formation principles using the system approach methodologyof competences in the higher educationsysteme in thecircular economyformation for future specialists.

Within the paper, scientists solved theoretical and methodological tasks, i.e.:

- timeliness of the research is justified consideringdemands of the market environment and social development vectors directed to the competneces's formation in the higher educationsystemto conduct activities in thecircular economy;
- analytical study of published issues of the competences' formation in the higher educationsystemfor activities within the circular economy, which is one of the sustainable development concepts, was carried out;
- methodology for tjr object research was highlighted;
- nature of reasons for required and structural components of formation of professional competences in the higher educationsysteminthe circular economy are highlighted, which include theoretical-methodical, practice-oriented, cognitive-value components;
- functional elements of students' competences to carry outactivities of the circular economy are defined, which include, as follows: knowledge element, applied, existential, stimulating element;
- information-structural system for the competences' formation in education for activities of employees in the circular economy as a recurring ratio was developed.

Literature Review

Relevance of the conducted scientific paper is confirmed by urgent formation of students' competences regarding greening within the circular economy and implementation of the sustainability concept. Of great importance are the studies of scientists (Marhasova V. et al., 2023; Kholiavko N. et al., 2023; Popelo O. et al., 2022), where authors emphasize development of students' competencies within sustainable development.Role of universities indevelopment of eco-industrial parks, implementation of the sustainability concept and basic principles of the circular economy has been studied within the scope of research (Shevchuk N. et al., 2021; Tulchynska S. et al., 2021).

Scientists (Petko L. et al., 2021) are convinced of necessary development of competences in solving environmental problems by today students by achieving main goals of the circular economy. The article (Sharapovna N. A. et al., 2022) examines urgency of optional course for students, which is devoted to innovative technologies in environmental education.

The authors of articles (di Santo N. et al., 2024; Jia Huanyu et al., 2024) investigate whether university students strive for sustainable development, and also evaluateinfluence of peers on participation of college students in the circular economy.

According to (Setiadi Hermawan et al., 2023), it is advisable to form eco-literacy among students to preserve natural environment. The purpose of the article (Mongar Kishore, 2023) is to analyze competences and ecocentric worldview within sustainability.

Scientists (Blanco María Eugenia, et al., 2022) proved urgency to form individual behavior of students aimed at environmentalization and sustainability. Authors (Amador-Alarcón M.P. et al., 2022) investigated relevence of educational components by formingstudents' competenciesin the circular economy.

Within the scope of studies (Navarro Luis Virgen et al., 2024; Alves M.N. et al., 2024; Yang C.-H. et al., 2024), the role of environmental awareness of students of HEal institutions and ecological focus on purchase prducts of the circular economy was analyzed. Successful practices were analyzed, awareness of university students on impact of the transdisciplinary course on the circular economy was investigated, and attitude of students to modern challenges by transition to thecircular economy was also evaluated.

According to authors (Romaniuk R. et al., 2021), it is advisable to involve students in research aimed at environmentalization and sustainability. Scientific work (Fabregá M.B. et al., 2020) is devoted to analyzing the level of awareness and orientation of students in environmental protection within the circular economy formation.

Taking into account a significant number of publications, it is appropriate to note that the issue ofthe competences' formation among higher educationstudents foractivities within the circular economy is gainingurgency and relevance.

Methodology

When researching scientific and practical issues onthe competences' formation in the circular economy in the higher educationsystem, it is recommended to use systematic approach, which facilitates holistic analysisof the higher education system, as well as educational process that ensures students' acquisition of competencies to promotethecircular economy development. Methodology of the system approach by acquiring competences makes provides for identification of various forms, interrelationships aimed at revealing values of the SD paradigm and the principles' formationof the circular economy in particular. Due to the implementedsystem of various forms, methods, means, learning in the higher educationsystem regarding acquisition of students' competences in the circular economy, synergistic effect is achieved, both for personal development and for social development as a whole. Methodology of the system approach provides consideration of each subsystem, each element of the system and their interrelationships in the competences' acquisition in the higher educationsystemfor their activities within the circular economy. During the competences' formation in the higher education sphere, the studnets' worldview as future specialists regarding ideas of environmentalization of socio-economic development, ecological culture of behavior are laid. The systematic approach of thecompetences' formation in thehigher educationsystem providesapplication of these principles of the competences' acquisition as follows: professional orientation, scientificity, innovation, creativity, complexity, individualization, typology, academic international cooperation, unity of structural elements of education in the higher education system.

Due to methodological principles of the system approach in the competences' formation in the higher education system during the training process, future specialists acquire competencesin the circular economy reproduction both for implementation of its principles in professional activities and in everyday personal life.

Application of the system analysis, system design, system programming, system thinking and other methods of cognition in the competences' formation in the higher educationsystem by implementing principles of the circular economy contributes to achievement of sustainable development goals in society.

Conducting this research makes it possible to use the systemic approach to build recurrent relationship, which makes it possible to specify actions on the competences' formation in education for activities of employees in the circular economy. Thus, everything that is stated in the article allows proposing the following recurrent ratio of the competences' formation in education for the circular economy (FCFECEn):

$$FCFECEn\begin{cases}\begin{cases}OPf(a_1,\ldots,a_{1+k}),n=1\\SPf(b_1,\ldots,b_{1+k}),n=2\end{cases}\\\begin{cases}SCPCf(TM),n=3\\SCPCf(PO),n=4\\SCPCf(CV),n=5\end{cases}\\TCf(c_1,\ldots c_{1+k}),n=6\\KCBCSf\begin{cases}ST,n=7\\D,n=8\\MPT,n=9\end{cases}\\KFEf\begin{cases}AFE,n=10\\EFE,n=11\\SFE,n=12\end{cases}\end{cases}$$

where *OP* - objective prerequisites forprofessional competence formation, which can be presented in the form of the components list- $a_1, ..., a_{1+k}$;

SP - subjective prerequisites for professional competence formation, which can be presented in the form of the components list - $b_1, ..., b_{1+k}$;

SCPC – structural components of professional competencies;

TM – theoretical and methodological component of professional competences;

PO – practical-oriented component of professional competences;

CV – cognitive-value component of professional competences;

TC - types of competences are aimed at minimizing the use of products and save materials as long as possible, saving products and materials with the highest utility, product reuse, etc. $(c_1, ..., c1_{+k})$;

KCBCS – key components that form foundation of the competence structure;

ST – system thinking;

D – design;

MPT - multi-perspective thinking;

FEC - functional elements of students' competences for activities in the circular economy;

KFE – cognitive functional element;

AFE - applied functional element;

EFE - existential functional element;

SFE – stimulating functional element;

n = 1, ... , 12 – components of the competences' formation in education for employees' activities in the circular economy.

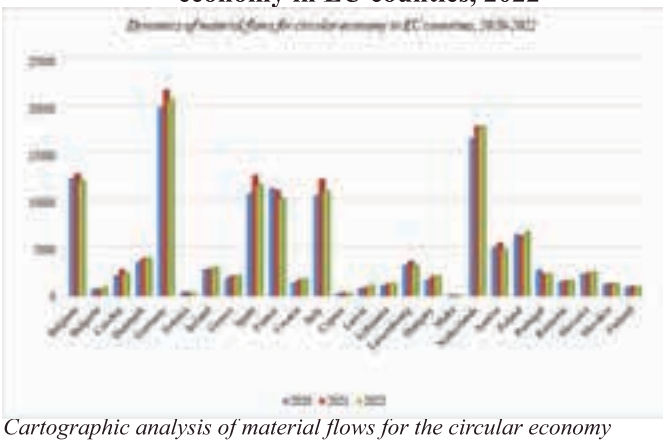
Therefore, representation in the form of a recurrent ratio of the competences' formation in education for employees' activities in thecircular economy makes it possible for higher education institutions to systematically access their formation.

Results

Theoretical basis for development of the circular economy theory is formation of closed production cycles with minimized quantitative indicators of production waste and maximized indicators of beneficial use of industrial waste. At present, relevant concept forms foundations for introduction of other ecologically oriented initiatives within manufacturing enterprises and other spheres of economic activity. However, it should be understood that the leading role in implementation of relevant basic provisions rests on personnel resource of entrepreneurial education, general value and knowledge base, which will determine prospective potential of personnel for qualitative analysis of current environmental situation and making relevant economic decisions. According to the analysis of material flows for the circular economy in EU countries for 2020-2022, it is possible to single out the top 5 leading countries: Germany, the Netherlands, Belgium, Spain, Italy. In Fig. 1 , dynamics of material flows for the circular economy in the EU and cartographic analysis according to corresponding indicator are graphically presented.

In the context of the problem raised, it is necessary to understand that formation of primary value orientations and relevant professional competences as their applied expression takes place at the level of a higher education institution, which requires the latter to significantly improve, modify and modernize existing educational programs and teaching tools in higher educationsystem to acquire them progressive competences to effective organization of management processes within thecircular economy.

Figure 1. Material flows for circular economy in EU counties, 2022



Cartographic analysis of material flows for the circular economy in EU countries, 2022

Source: *Eurostat (2022)*

Acquisition of educational competence in the student's education involves acquisition of specific theoretical knowledge base, its integration with practical skills, qualities of situational adaptation and modification of the learned theoretical and methodological provisions according to current indicators of the state of internal environment of the economic entity and changing external parameters. At the same time, it should be noted that the competences' formation of higher educationapplicants in higher education cannot be limited exclusively to objective characteristics as specific knowledge, ability to use certain methods and tools, etc. On the contrary, this direction includes subjective aspects expressed in formation of favorable personal qualities, internal system of motivation of future specialist, understanding of interdisciplinary relationship of the acquired knowledge, moral and ethical aspects by implementing certain decisions, which generally forms value orientation of applicants and future specialists.

Coming back to the issue of formation of professional competences in higher education within the circular economy, it is important to consider the following:

first, objective prerequisites to ensure appropriate competence (capability to predict potential negative impacts on the ecological and natural environment, search for and implement measures for resource optimization and ensuring energy efficiency of the business entity, etc.);

second, as well as prerequisites of subjective nature (development of ecological awareness, internal value system aimed at preserving natural resource potential and economical use of resources, etc.).Theoretical and conceptual approach to the competences' formation in higher educationwithin the circular economy is presented in Fig. 2.

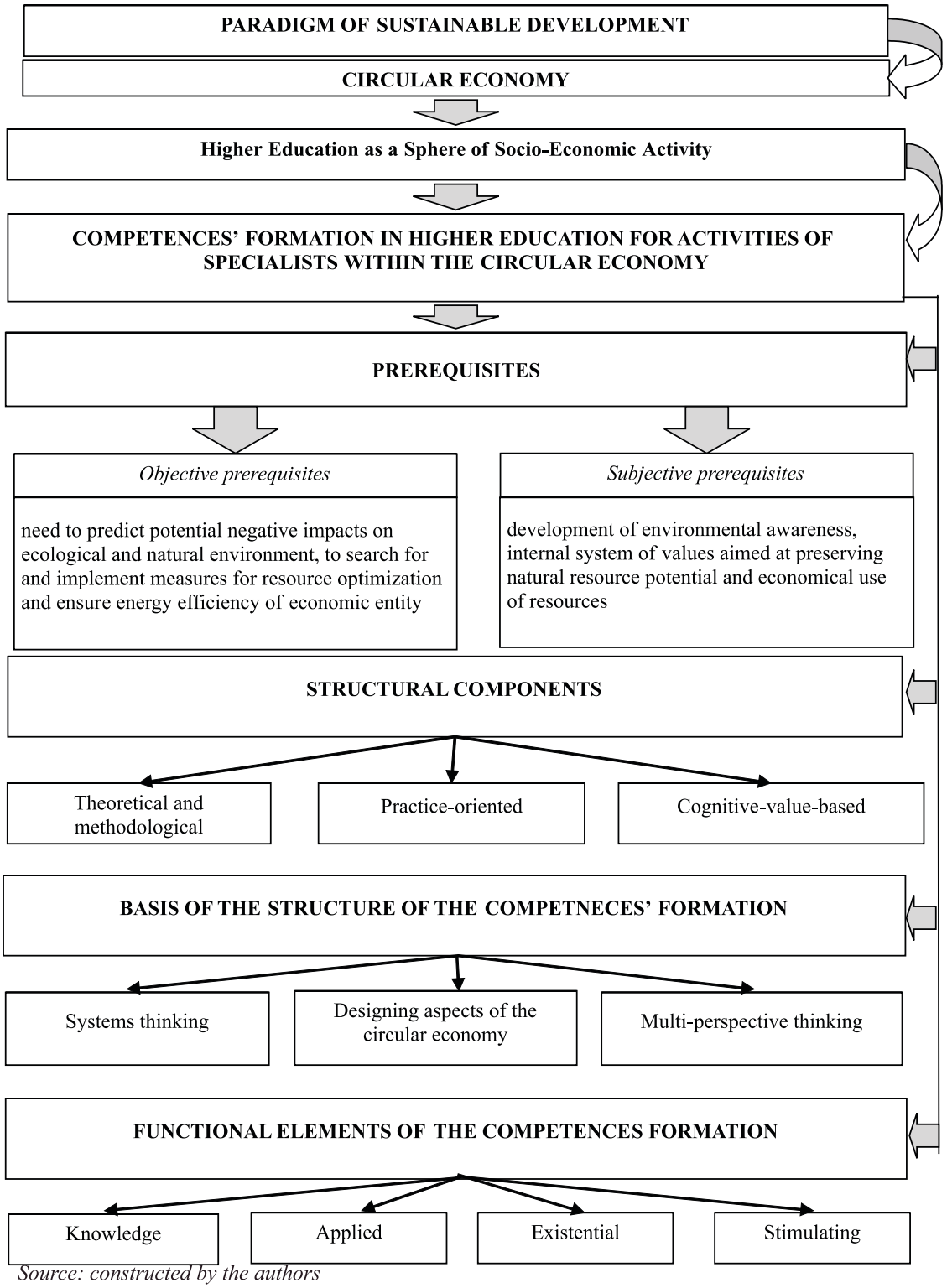
Thus, in terms of formation of professional competences in the higher educationsystem in thecircular economy, the following structural components can be distinguished:

First, theoretical-methodical one - covers knowledge level in terms of specific functioning of business systems as part of local, regional and national biocinosis, specific application of methodical and instrumental assessment, modernization and adjustment of existing spectrum of natural and ecological impacts carried out by business structures, and also achieving both organizational and production processes on the resource use, ensuring their waste-free and frugal use.

At the same time, environmental component should be considered in a multidisciplinary manner, integrating appropriately into the education structure of various program components to develop holistic view of place and role of ecologically oriented principles of the circular economy at different horizontal and vertical levels of economic unit.

Second, it is practical-oriented - it involves acquiring in the higher educationsystem by students skills of practical application of mastered theoretical and methodological base by implementing basic principles of the circular economy in the entrepreneurial education. In this direction,integration into the educational process of practical cases of enterprises of various forms of ownership and functional areas of activity by implementing relevant ecologically oriented measures is envisaged, in parallel, creation of favorable environment for direct application of this knowledge by applicatns by solving educational tasks and problems in the conditions of real management practices, as well as establishment of appropriate interaction with the most progressive economic entities that permanently implement conceptual provisions of the circular economy theory.

Figure 2: Theoretical and conceptual approach to determining the role of the circular economy disciplines in the higher education system



Source: constructed by the authors

Third, it is cognitively valuable. This component represents the highest level of practical structuring and formalization of acquired professional ecologically oriented competencies in the higher educationsystemwithin thecircular economy. The stated fact is explained by leading role of values and personal qualities as primary target orientations and guiding principles in further professional development of student, his ability to holistic individual assessment of current situation in environmental friendliness and circular development of economic education.

It should be noted that within this aspect, it is necessary to form philosophical and scientific basis of the system of theoretical and practical knowledge and skills mastered by applicant, which allows considering problems of the circular economyformation in the unity of individual, local and global parameters. Proper formation of the cognitive-value component of professional competences in higher education within thecircular economy in the future will contribute to maximizedindividual creative potential and promote collective forms ofintra-group interaction of the labor team at expense of the coherent and stable system of internal motives and moral and ethical guidelines (Fig. 3).

As we can see from Fig. 3, three types of competencies are identified as the basis of students' training within the cyclical approach, which are aimed at:

- promoting minimized use of products and preservation of materials as long as possible (conservation);
- promoting preservation of products and materials with the highest utility (optimization);
- reusing the product (when it reaches the end of its useful life), creating further value (increasing efficiency).

Thus, foundation of the competence structure in the circular economy consists of several key components:

- first, it is systemic thinking, which allows considering problems in their complex context;
- second, design, which includespossible effective solutions for various aspects of the circular economy;
- third, multi-perspective thinking, which provides for possible assessment of situations from different points of view.

Figure 3: Inclusion model of the circular economy disciplines in the higher education system

General characteristics of the types of competences in the higher education sphere for the circular economy

Preservation	**Optimization**	**Increasing efficiency**
Actions and behaviors aimed to conserve materials, resources and products for the circular economy Knowledge, evaluation and comparison of one's own behavior, thoughts, values and emotions regarding the circular economy Initiate and encourage others to engage in environmentally friendly behavior to promote principles of the circular economy. Identification, analysis, measurement and consideration of ideas to solve the problem of resource conservation in the circular economy sphere.	Identification of material and non-material resources (including human resources) for transformation of ideas into actions in the circular economy sphere. Combining different contributions and finding ideas to create environmental value for the reuse and optimization of resources and products. Communication by achieving main environmental goal to optimize resources and promote transition to the closed-loop economy. Responding to a complex situation withinthe cyclical economy to optimize resources and products in a new/original way	Application of the most acceptable environmental management Making connections between ideas and concepts from different fields, connecting different disciplines and ideas with the circular economy approach. Applying formal learning to practice and related experiential learning to promote and share knowledge in the circular economy and beyond towards sustainable development

Source: constructed by the authors

Therefore, following functional elements of students' competences for activities within the circular economy can be distinguished:

1. Knowledge. The knowledge element involves formation of a complex and systematic theoretical basis for analysis and assessment of environmental aspects of activities of economic entities in the circular economydevelopment. Specifying relevant aspects, it is worth noting that applicants should master skills by identifying causal relationship between processes and phenomena inherent in a specific biocinosis or ecosystem;consider available side effects of a chemical, physical or biological nature by implementing specific management decisions; to have knowledge on search and implementation of optimal directions to minimize external impact on natural and ecological environment; to understand and apply progressive practices of conscious environmental behavior both within the working environment and in individual household behavior; to understand current range of environmental security threats in functioning of local, regional and national economic systems. It should be noted that in addition to exclusively economic aspects by acquiring appropriate knowledge base, important role is played by interdisciplinary dimension of the educational process, because the outlined issues cover a wide range of related elements of educational knowledge, starting with regulatory and legal features of regulating the environmental aspect ofeconomic education, ending with technical and technological specifics of the implemented basic processes.

2. Functional. This functional element of the students' acquisition of professional competencies for activities within the circular economy requires, on the one hand, significant practical basis to apply individual knowledge potential, and on the other hand, to promote development of individual educational skills.

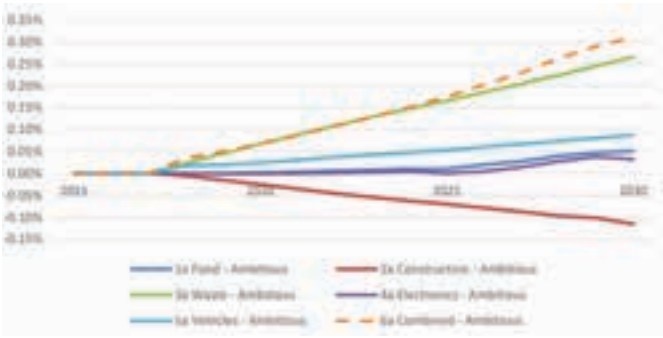
According to the analysis of the employment impact in EU countries on development scenario of the cyclical economy (Fig. 4), it can be stated that demand for jobs is high. Based on the results of the analysis of both scenarios, it can be seen that employment will increase by almost 0.3% by 2030, which is approximately 650,000 - 700,000 jobs. This proves significant demand for labor in the waste management sectors, which once again proves urgency for acquiring knowledge and skills within the circular economy by students of leading universities.

That is, this functional dimension by acquiring professional

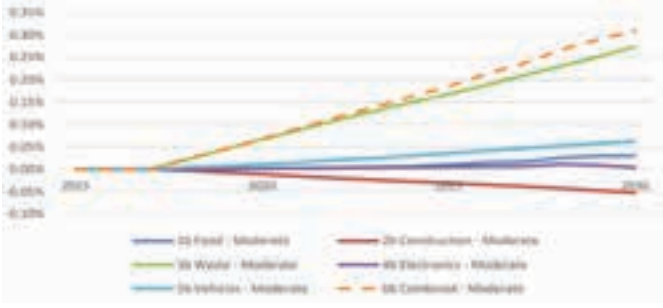
competences covers directions as follows: practical perception of implementation principlesof the circular economy in economic practice of the entrepreneurial structure; integration of traditional methods and techniques of economic and statistical analysis by solving practical environmental problems; identification of target areas of economic greening of the main activity within the tasks and target orientations of the enterprise's activity; expanded range of practical skills in prognostic methods, which allows assessingprospective consequences by implementing specific management decisions on external natural and ecological environment; striving for a permanent update of current knowledge base inenvironmental education and appropriate applied instrumental support for environmentalization of the enterprise's activities; possible adaptation of existing theoretical and methodological base according to specific environmental needs and requests of the relevant economic structure.

Figure 4. EU employment impacts in the circular economy scenarios (% from base)

EU28 Employment – Ambitious (% difference from base)



EU28 Employment – Moderate (% difference from base)

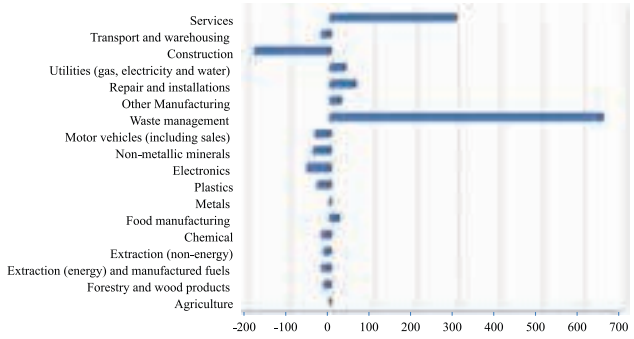


Source:European Commission.

Thus, the applied aspect directly determines possibility and quality of specific actions and functions of the applicant as a prospective specialist within the chosen functional sphere of the activity of the entrepreneurial entity.

In Fig. 5 impact of the cyclical economy on jobs in EU-28 sectors is presented. Leading positions are occupied by waste management and services.

Figure 5.Circular economy job impacts across the EU28 sectors in 2030 (thousands)



Source: Eurostat (2024)

3. Existential. This functional element characterizes internal value structure of the individual, formed stable beliefs that will determine general vector of the activity by achieving conceptual foundations of the circular economy at the entrepreneurial education level.

Existential element presupposes, first of all, familiarization of the applicant with primary personal aspects of influence of ecologically oriented competences within the circular economydevelopment by implementing basic household practices and their place in general structure of the individual, i.e., as an agent of change within the specific entrepreneurial formation and the national economic system as a whole.

Moreover, the identified element involves ability to organize and objective self-reflection, which allows for a comprehensive analysis of one's own value system,carrying out critical analysis of current problems and the set list of tasks to optimally involve both cognitive and applied elements of professional competences within the circular economy development.

4. Stimulating. Stimulating functional element of development of professional competences among students in the circular economyformation, construction of internal motivational guidelines, means of stimulating individual activity in environmentalization of the entrepreneurial education within the limits of a specific area of responsibility is envisaged. That is, it is important to cultivate in the applicantappropriate worldview vectors of professional activity capable of exerting managerial influence by carrying out hislabor activity. Stimulating element is reflected in fundamentalization ofecologically oriented competences based on professional growth of the future specialist within the circular economy; awareness of multilevel nature of interrelationship of environmental, social and economic factors within the respective horizontal and vertical system formations in localized and aggregated forms; formation of personal focus on general environmentalization of individual activity of future specialist, both within professional activity and related to everyday household practices; cultivation of beliefs in the personal involvement in preservation of surrounding natural and ecological environment by implementing professional competences in ensuring sustainable functioning of the entrepreneurial education withinthecircular economy; orientation topermanence of individual development of the future specialist and improvement of existing set of environmentally oriented competencies.

Conclusion

According to the results of the study, it is poposed that summarizing results of following stages of measures to promote effective acquisition of relevant competencies of studentswithin thecircular economy should be proposed:

1. Diagnostics of current state and degree of representativeness of ecologically oriented professional competences within thecircular economydevelopment in terms of educational and methodological materials to provide educational process, its composition, structure, content, specifics of educational tasks and relevant didactic techniques. At this stage, a systematic analysis and evaluation of actual degree of providing applicants with relevant competence and knowledge characteristics for successful activity is envisaged.
2. Analysis of effective practices of involving ecologically oriented competencies in their educational and practical dimension in the educational process, which will allow, on the one hand, to expand theoretical and methodological aspect of studying a specific discipline, and on the other hand, to provide opportunities for the acquirer to master relevant skills and abilities to carry out activities.
3. Development and comprehensive integration of professional ecologically oriented competencies within the circular economydevelopment into the educational process, both at the level of individual educational disciplines and educational programs as a whole, which involves enrichment of methodical and instrumental support, established in relevant internal provisions, thereby forming a standardized methodological field and clear regulation to acquire appropriate professional competence by the applicant.
4. Support of appropriate communication level on the environemnt interaction for students, both in promising directions to improve existing elements of educational courses, and in formation of students' interest and motivation in the in-depth mastery of ecologically oriented competences as a sustainable basis for personal and professional development.
5. Expansion of theoretical-methodical basis to acquireenvironmentally oriented professional competences, which includes, on the one hand, deepening and enriching existing knowledge potential of appicants on the issue of building sustainable socio-economic ties between economic units and surrounding natural and ecological environment, and on the other hand, promoting development of environmental awareness and internal guiding principles in management and development of socio-economic systems in accordance with conceptual provisions of the circular economy, awareness of relevent practices and role of individual activity in achieving positive socio-ecological consequences.
6. Implementation of effective practice-oriented forms of

consolidation of previously acquired knowledge elements of environmental competences in the circular economy, which includes solving practical tasks and cases, performing a set of heuristic didactic tasks, as well as interaction with business entities in terms of forming effective recommendations to implement key tasks and principles of the circular economy.

7. Organization of permanent monitoring of effective assimilation and acquisition by students of professional ecologically oriented components of the circular economy development, implementation of corrective actions based on appropriate measures to modify and improve adopted methodological approaches by implementing educational process.

Scientific novelty of the study consists in substantiating, using methodology of the systemic approach, principles of the competences' formation in higher educationfor activities of specialists in thecircular economy, which should:

- first, include following structural components of professional competences in the higher educationsystem, such as: theoretical-methodical, practice-oriented, cognitive-value;
- second, considerfunctional elements as follows: cognitive, applied, existential and stimulating;
- third, provide sequence of measures in terms of education organizationto achieve its effective formation of students' competencies for the activities in thecircular economy, which includes stages of diagnosis of current state and degree of representativeness of ecologically oriented professional competencies; analysis of effective practices of involving environmentally oriented competencies in their educational and practical dimension in the educational process; development and complex integration of professional ecologically oriented competencies in circular economydevelopment in education; maintaining appropriate level of communication with higher education applicants; expansion of theoretical and methodological basis of learning ecologically oriented professional competences; implementation of effective practice-oriented forms of consolidation of previously acquired knowledge elements of environmental competences in the circular economy; organization of permanent monitoring of effective assimilation and acquisition of professional ecologically oriented componentsin the circular economy development.

Thus, ensuring effective formation of professional competences among students for successful activity in the circular economy is a complex and consistent process that requires systematic work by expanding knowledge base, enriching applied skills and abilities of students, cultivating environmental culture and consciousness as an integralelement of appropriate competence at all levels of the entity, as well as appropriate organizational and managerial provision of support and improvement of relevant process at the level of the higher education institution.

The issue of the methodological approach development to assess effective formation of competences in the higher educationsystemfor activities within the circular economy, which corresponds to sustainable development principles, requires further research.

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