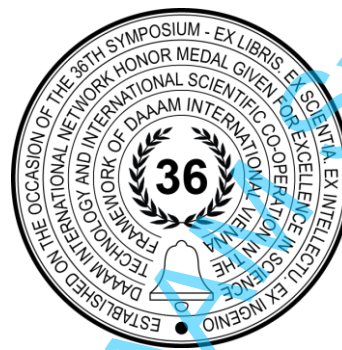


OPTIMAL DESIGN PROCEDURES IN MACHINE SCIENCE EDUCATION

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Abstract

A theoretical survey in the area of application of optimal educational technologies and design in Machine Science Education has been implemented. Based upon this analysis, the main objectives of the study have been derived: to define updated strategies for developing and improving collaborative teaching practices, to create an appropriate model that meets educational objectives and combines relevant co-teaching approaches; to indicate opportunities for improving the acquisition of specific competencies of engineering students corresponding to the challenges of Industry 4.0. A modified collaborative teaching model has been created. The research has been carried out based upon a methodology containing six stages. Practical applications of the model created have been described. Based on the results of the study, a system of additional activities is proposed to in order to improve the quality of training in the higher education system. Conclusions and recommendations are made, and the authors' vision for future work in this area is presented.

Keywords: Optimal Design procedures; Machine Science Education; Modified co-teaching model; Industry 4.0.

1. Introduction

The application of optimal educational technologies and training design in the area of Machine Science depends on access to modern study materials and on the opportunities for students to communicate with well-known professionals in a certain scientific field, [1]. A significant number of studies have investigated the impact of study process management based upon outcomes and innovation in engineering higher education [2], [3].

The authors of [4] emphasize the extremely important role of creating a sustainable functional and theoretical approach concerning teaching and learning by applying a fundamental framework related to knowledge. According to the authors of [5], the appropriate decision-making in managing the flow and volume of knowledge in fundamental engineering subjects involves critical evaluation of learning outcomes, which requires time and additional effort.

In [6], the importance of knowledge management, providing a link between universities and engineering practice, has been emphasized. In addition, methods for managing time for independent study of students have been discussed. The most important results of this study are relevant to the possibilities for applying optimization procedures in the field of Machine Science and Engineering Design Training.

Besides, interactive work with 3D models is important for clarifying spatial representations and relationships, especially if sufficient effort is made to combine graphic drawings, models and textual descriptions according to [7]. Models of collaborative teaching have been discussed in various literature sources, but the degree of responsibility of the academic staff in a co-teaching environment and the appropriate way to define effective collaborative training require further study according to the authors of [8].

The investigation, described in [9], defines co-teaching models that include: teamwork in a large group, simultaneous lectures, presentation of different perspectives and different methods for solving problems. The selection of different approaches and responsibilities for each lecturer depends on the aims and objectives of the study contents to be fulfilled, the individual needs of the students, the expertise of the academic staff and the results which are to be obtained. It is particularly important to emphasize that no single model of co-teaching should be used quite often. It is recommended to develop different modifications or combinations of co-teaching approaches for certain periods of time [10], [11].

Based upon a theoretical analysis of European university practices, the following specific indicators can be summarized: important prerequisites for implementing optimization procedures in the education technology in Machine Science is the availability of curricula in engineering Bachelor degree courses synchronized with the requirements of the Bologna Process. A particularly significant condition for the successful creation of an appropriate modified model of co-teaching is the perfect and transparent approach for introducing international dimensions into the university experience of the academic staff, applied by the Vice-Rectors for International Cooperation at the University of Ruse over the past 12 years: [12], [13] and [14].

Due to the beneficial academic environment created by the Rectors' Management teams of the University of Ruse, almost all members of the academic staff show awareness of the need to introduce new, innovative models of education. The most important reasons for facing this challenge are: students' chances of finding a job in the internationally oriented labour market are increasing, [15]; students need important competencies to work successfully in a multicultural society, [16]; global challenges in the labour market require a multidisciplinary and international approach, [17], [18]. It becomes clear that at the University of Ruse, Bulgaria there is a sustainable trend towards creating beneficial conditions for the implementing new and modified lecturing and training approaches.

The main objective of the study can be summarized in the following way: to define updated strategies for developing and improving collaborative teaching practices, to create an appropriate model for different purposes that meet educational objectives and to combine relevant co-teaching approaches.

Therefore, the second objective of the study presented is to indicate opportunities for improving the acquisition of specific competencies of engineering students corresponding to the challenges of Industry 4.0.

2. Creating a modified collaborative teaching model

In order to achieve the research objectives, a modified model of co-teaching has been created based upon the professional experience of the authors' team [19], [20] and [21]. The model is characterized by the following features:

A system of additional educational activities has been created, including the integration of specially developed training for co-teaching in the field of Machine Science. The authors' team integrated newly developed training strategies for co-teaching, providing individual additional training programs.

The following components of the modified co-teaching method have been provided: control of the analytical part of the main components of the product developed; ensuring co-teaching combined with consultations regarding the elaboration of the representation from the assembly drawing of the product, containing as much information as possible; organizing additional co-teaching aiming to explain and correct errors, to indicate omissions; continuing co-teaching and consulting activities for completing the project task.

This approach achieves the objectives of the individual educational programs, considering the prior level of preparation of each student in the target group. Therefore, the significant spectrum of academic and behavioural diversity in a student group is taken into account.

The authors' team strives to ensure the credibility of the research by using methods for data collection and analysis, described in details in [22] and [23]. The transferability of the research results can be established by identifying the academic study environment and describing the activities carried out by the participants in the research process. Within the framework of the investigation preparatory work, information on the equipment facilities is updated, the types of training modules are planned in appropriate time intervals. Administrative support is provided if necessary. Audit options are described with the aim of: guaranteed verification of the stages used and the decisions made within these research activities.

3. Practical application of the developed model in a new BIP

The authors' team developed a new project for the Blendid Intensive Program (BIP): "Smart Design Case Studies". The work on the project will be carried out within the framework of a joint international group of several European universities, aiming to foster a deep understanding of creative projects in the fields of Machine Science, Design and Digital Products, [24], [25]. These initiatives are closely related to the requirements and needs of local markets, which guarantees their relevance. The project envisages a preliminary two-month virtual training, followed by a one-week face-to-face work.

Students participating in the intensive program will have the opportunity to: build a network of contacts internationally; learn and work in a team, participating in interesting challenges supervised by leading scientists. The created modified model of co-teaching will be implemented within the framework of this BIP.

4. Research Methodology

Aiming to achieve the objectives of the study and based upon the professional experience of the authors' team [26], an advanced methodology has been developed, which includes the following stages:

Determining recommendations for a system of teaching methods, training and additional activities aimed at improving the quality of education in the higher education system based on the results of the study and the practical application of the study in international educational and scientific activities.

1. Determination of an academic staff team engaged in the implementation of the modified collaborative teaching model. The definition of this target group of simultaneously teaching lecturers depends on the well-known characteristics of effectiveness in carrying out the relevant training: they should share their vision and commitment to co-teaching; participate in planning the study process on an equality of opportunities; responsibilities are to be defined in advance clearly and precisely, [27];
2. Selection of the research target group in order to identify the challenges in the training of students from different Bachelor degree courses;
3. Implementation in stages of collaborative teaching with the target group, including the described components of the modified co-teaching model. The integration and application of the described collaborative teaching strategies aim to adapt of the education system to the generation of students with a digital orientation in the field of engineering design;
4. Conducting a pilot study, discussing the advantages and features of a modified model for co-teaching with students from the target group;
5. Analysis and discussion of the research results obtained;
6. Determining recommendations for a system of teaching methods, training and additional activities aimed at improving the quality of education in the higher education system based on the research results and the practical application of the study in international educational and scientific activities.

5. Analysis and discussion of results

The academic staff team, engaged in the creation and implementation of the modified model of collaborative teaching in the field of Machine science, consists of three habilitated lecturers in this scientific field.

The target group has been selected among students from different Bachelor degree courses in three engineering faculties of the University of Ruse. The prerequisite for participation in this group, set by the academic staff team, was compliance with the principle of voluntary participation in a "project".

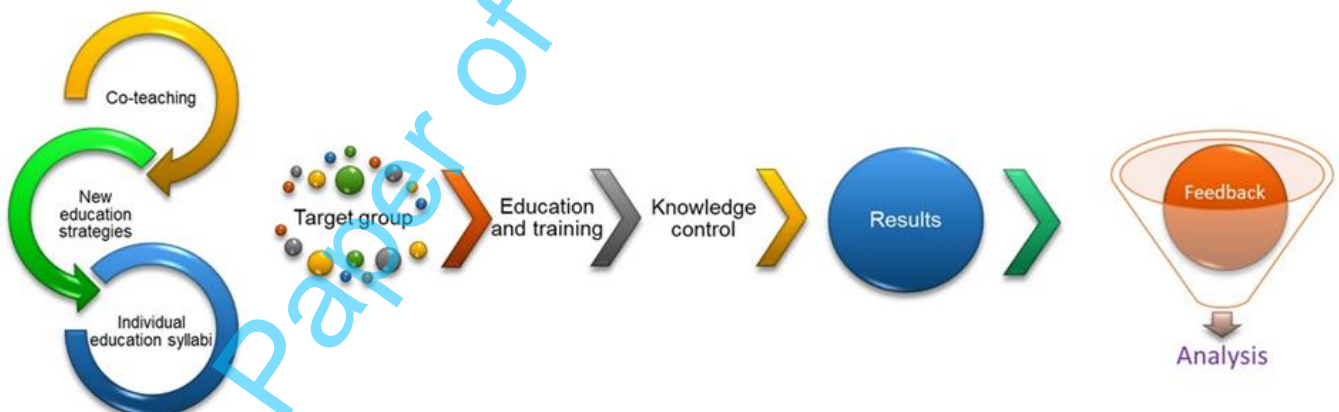


Fig. 1. Research implementation stages

Students have been informed about the expected benefits: teamwork, development of creative thinking, upgrading of spatial vision skills and improvement of design abilities. After successful completion of the project, students receive a certificate for a completed elective course with the corresponding ECTS. This achievement can be included in their Bachelor's Degree diploma and professional CV.

A phased implementation of collaborative teaching with the target group within the framework of the research work has been carried out, Fig. 1. After the implementation of the described model of collaborative teaching, the students' motivation for independent learning improved.

An additional survey has been conducted, discussing the advantages and features of the modified co-teaching model with students from the target group. Particularly good feedback was received when discussing the individual supervising support provided to almost all students from the target group.

Additional positive results have been obtained in improving communication and professional development of the academic staff members who participated in the study.

The following challenges had to be faced: organizing preliminary meetings to ensure good planning; managing time for carrying out the relevant activities for teachers and students. It became clear that the differences in the teaching styles of each teacher should be taken into account and achieving their unification to a certain extent is quite necessary.

The positive consequences of the research can be summarized in the following way: improving the quality of education, increasing the motivation of students to do independent work.

The expected negative consequences could be: not all lecturers are to be equally loaded; creative contradictions may arise regarding education technology and teaching methods; the organization of the learning process between lecturers is complex, which would require an additional investment of time.

6. Conclusions and future work

The research of the scientific problem has been imposed by the need to optimize and modernize educational practices in the area of Machine sciences. Special attention has been dedicated to the development of collaborative teaching models that would meet the requirements of the European educational systems.

According to the authors of the paper the solution to this challenge is the elaboration and implementation of a modified co-teaching models based upon modern pedagogical approaches and practical experience of the authors' team.

Based upon the research implemented, the following conclusions can be formulated:

The main objectives of the study have been achieved through the implementation of a methodology containing six stages.

Updated strategies for developing and improving co-teaching practices have been defined. The solutions included the creation of a system of additional educational activities, the integration of collaborative learning strategies and adaptation to the students' digital environment.

The practical application of the model within a new Blended Intensive Program (BIP) demonstrates its effectiveness and the possibilities for improving students' skills and competencies corresponding to the challenges of modern industry.

An appropriate modified collaborative teaching model has been created which corresponds to the educational objectives and combines the relevant co-teaching approaches. The practical applications of this model have been described.

The results of the study showed that the implementation of the modified model improved motivation, communication and independent learning among students. In addition, the professional experience of the lecturers has been significantly enriched. The results confirmed the prospects for further improvement of co-teaching practices and integration of international dimensions.

The possibilities for improving the acquisition of specific competencies of engineering students corresponding to the challenges of Industry 4.0 are indicated.

Future scientific work in this area include expanding the application of the developed model to other academic subjects and to other Bachelor and Master degree courses, improving learning management strategies, and continuing international cooperation. The authors' team intent to systematize and popularize good practices, ensuring their sustainability and adaptability to the dynamically changing requirements of industry and education.

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