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Ontological model of the process of intensification of teachers' competencies

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ABSTRACT

Currently, there is a need to improve the education system and develop interdisciplinary research at all levels of education, from school to postgraduate education. The introduction of interdisciplinary connections contributes to the formation of a holistic understanding of natural phenomena and the connections between them. Thus, this knowledge becomes more meaningful and applicable in practice. This article proposes a conceptual model of the content of education in the form of a thesaurus and ontology. The use of these models will allow you to adaptively select and systematize educational information. The article also discusses the possibilities and experience of using ontological modeling and engineering for the conceptual description of school and higher education. In addition, the article discusses the development of an ontological model of the process of expanding teachers' competencies with the integration of science, technology, engineering and mathematics (STEM) education. The use of ontological engineering methods will improve the quality of teacher education through the semantic description of knowledge in the subject area and the use of interdisciplinary and STEM approaches in the educational process.

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1. INTRODUCTION

One of the directions of development of modern education is the development of individuality and competitiveness of the individual in a constantly changing world. In the modern world, the problem of developing a creative personality, capable of independently replenishing knowledge, extracting useful things, and realizing one's own goals and values in life, is very relevant. This can be achieved through the cognitive and research activities of students in various key academic fields, such as science, mathematics, technology and engineering [1]-[5]. For this purpose, it is planned to introduce STEAM elements into the educational program, aimed at the development of new technologies, scientific innovations, and mathematical modeling.

STEAM education is the bridge that connects learning and careers. The need for innovators in education in the modern world leads to a shift in existing priorities. It is necessary to develop critical thinking skills, digital skills that are important for innovation, and find ways to develop them. The relevance of studying the sphere of ontological modeling of the process of intensifying the competencies of teachers with elements of science, technology, engineering and mathematics (STEM) education is due to several factors. First, in recent years, attention to STEM education has been increasing around the world, as these areas of knowledge are key to the development of innovation and the economy. Secondly, the development of information and communication technologies leads to the emergence of new teaching methods and educational models. Thirdly, the existence of an ontological model of the process of intensifying teachers' competencies with elements of STEM education can significantly facilitate the creation and implementation of individual educational programs.

It is impossible to master competencies without acquiring operational experience, since they are inextricably linked. The learning process turns into a process of acquiring knowledge, skills and abilities to obtain significant competencies [1]-[3]. A competency-based approach to the implementation of the educational process is the basic principle of our current education system. When comparing educational systems of countries, general principles for assessing educational outcomes are needed. Outcomes refer to competencies that include the knowledge, skills, and abilities of students.

- The object of the study is the process of intensifying the competencies of teachers.
- The subject of the study is the concepts, connections and properties associated with the process of intensifying the competencies of teachers with elements of STEM education.

It is advisable to put forward a research hypothesis that the use of ontological modeling in the process of advanced training of teachers with elements of STEM education will effectively structure and organize the knowledge and skills necessary for successful teaching of science, technology, engineering and mathematics subjects, which will lead to improved quality of education and increasing the professional competence of teachers.

- The goal of the project: to create a formal model that allows you to describe and structure the knowledge, concepts and connections associated with the process of intensifying the competencies of teachers in the field of STEM education. Ontological modelling allows you to create a formal knowledge structure that reflects the connections between concepts and the subject area, which in turn allows you to more effectively organize and standardize the process of training and advanced training for teachers, i.e., the process of intensifying teachers' competencies.
- Scientific novelty: consists of the use of ontological modelling methods for the process of intensifying the competencies of teachers with elements of STEM education, providing the opportunity to develop new competencies among teachers, as well as methods of intellectual processing of knowledge based on the use of descriptive logic, statistical methods of classification, text mining and semantic web technologies.

The concept of a market-oriented innovation university is based on the knowledge triangle (education-science-innovation) and aims to invest on a large scale in human resources, develop professional skills and research, and support the modernization of the education system to meet the needs of the global knowledge-based economy. Knowledge-based education is being replaced by competency-based education, which provides a more complete personally and socially integrated educational result. For high-quality training of a specialist who is ready to work in dynamically changing economic conditions, it is necessary to provide the graduate with not only knowledge, but also a set of competencies.

Mastering competencies is impossible without acquiring operational experience, since they are inextricably linked. The learning process turns into a process of acquiring knowledge, skills and abilities to obtain significant competencies [2], [3]. A competency-based approach to the implementation of the educational process is the basic principle of the modern educational space. When comparing educational systems of different countries, common principles are needed for assessing educational outcomes. Results are understood as competencies, including the knowledge, skills and abilities of the student.

The purpose of the study is to identify interdisciplinary connections using ontological modeling and use the STEM approach in the learning process. Hypothesis: the use of ontological engineering methods will improve the quality of schoolchildren's learning due to the semantic description of knowledge about the subject area. The construction of knowledge-based systems is associated with the development of knowledge representation models and the creation of knowledge bases. There are various approaches, models and languages for describing data and knowledge: production and formal logical models, semantic networks and ontologies.

One of the key tasks in the process of professional development of teachers with elements of STEM education is the creation and updating of ontological models. Ontological modeling is a methodology that allows you to organize and systematize knowledge in a particular field. In the context of STEM education, the development of ontological models helps teachers' structure and integrate knowledge and concepts from various sciences for more effective learning. One of the main problems encountered in the process of ontological modeling is the difficulty of creating and maintaining relevant and full-fledged models. There are many aspects to consider, such as the structuring of knowledge, the definition of classes and relationships between them, as well as taking into account different points of view and approaches in different fields of knowledge. In addition, the modeling process requires a deep understanding of the subject area and its features, which can be a challenge, especially for those who are just starting their way in the field of STEM education.

Another important issue is the support and consistency of ontological models with innovative and scientific developments in the field of STEM education. Due to the rapid development and constantly changing technologies and scientific discoveries, models must be flexible and adaptable to new knowledge and approaches. This requires not only mastering the basic principles of ontological modeling, but also constantly updating and expanding one's knowledge.

In addition, an important problem may be the lack of standards and a unified methodology for ontological modeling in the field of STEM education. This can lead to different approaches and interpretations, which makes it difficult to compare and exchange ontological models between different teachers and educational institutions. Therefore, the development of generally accepted standards and methodologies can help improve the effectiveness of the modeling and training process. In general, successful ontological modeling in the process of professional development of teachers with elements of STEM education requires adequate training, considering changes and developments in the field of STEM education, as well as the establishment of generally accepted standards and methodologies in ontological modeling.

The problems of formalizing the knowledge base and developing methods for intelligent information processing are solved using various models and approaches, but ontologies have become very popular [4], [5]. Ontology modeling allows you to create a conceptual description of a specific subject area, which in turn allows you to effectively search and classify information. Elhassouni *et al.* [6] proposes a sequence of actions for extracting knowledge from data and integrating ontology elements. Works [7], [8] explore improving the decision-making process using ontologies. Zulkipli *et al.* [9] presents a systematic literature review based on a comparative analysis of various methods and approaches to constructing ontologies.

Ontology engineering is the process of designing and creating ontologies. Ontological engineering combines the principles of object-oriented and structural analysis, as well as the basic technologies for designing complex systems. During ontological engineering, the main classes of entities are identified, as well as connections and clusters of characteristics between these classes [10], [11]. Foreign works [12]-[15] also study ontological engineering.

Scientists at the US National Science Foundation coined the acronym STEM in 2001 to describe a trend in educational and professional fields. The term STEM is used to combine the academic disciplines of science, technology, engineering and mathematics. They also denote an approach to the educational process, the basis for acquiring knowledge is the visualization of scientific phenomena, which makes it easy to grasp and gain knowledge through practice and a deep understanding of the processes [16], [17].

In this regard, it is necessary to develop the digital skills of schoolchildren for the further development of educational abilities and personal growth. School students are required to develop in various key academic areas such as science, mathematics, technology and engineering, that is, with the new trend of STEM education. Currently, professions related to technology at the intersection of natural sciences are emerging. The introduction of STEM education from the school curriculum will make it easier for schoolchildren to adapt to further higher education and obtain a future profession. Increasing the student's STEM literacy will ensure relevance and competitiveness in the labor market [18], [19].

STEAM education is a mechanism that provides a link between learning and professional careers. In the modern world, there is a need for innovators in education, which leads to a change in priorities. One of the important areas of student activity is scientific and technical creativity, and one of the most innovative areas in this area is educational robotics, including the study of the fundamentals of technology, information modeling, programming and information technology. Developing critical thinking and digital skills, which are essential for innovation, is a must. Developments in the application of robotics, artificial intelligence, unmanned vehicles, e-commerce and big data processing technologies are proving important.

STEAM education offers an integrated approach to solving modern problems, based on the interaction of various fields of natural sciences, engineering, mathematics, digital technologies and the study of networks and blockchain, and foresight. The education system is influenced by the digital revolution and the IV technological revolution, which combines several "exponential technologies" such as artificial intelligence, biotechnology and nanomaterials. As a result, significant changes are needed in data science, artificial intelligence, robotics, and nanomaterials curricula.

Ontological modeling of the process of intensifying teacher competencies with elements of STEM education is of practical importance in several aspects:

- Curriculum development: ontological modelling allows us to understand what competencies teachers need to successfully implement STEM education. Based on this information, appropriate training programs can be developed, where sufficient attention will be paid to the development of the necessary competencies.
- Assessing teacher competencies: the ontology model can be used to assess teacher competencies. Based on the model, it is possible to determine which competencies the teacher already has and which ones need to be developed. This allows a more informed competency development plan to be made and areas where additional training is needed.
- Improving the quality of education: ontological modelling helps to identify shortcomings in the education system and suggest ways to eliminate them. By analysing the model, it is possible to find out which competencies are not sufficiently developed among teachers and how this may affect the quality of education. Based on these data, measures can be developed to improve the quality of education in general.
- Personalization of learning: the ontological model allows for an individual assessment of the competencies of each teacher. Based on this information, you can develop personalized training programs and recommend specialized courses to the teacher to develop the necessary competencies.

Thus, ontological modeling of the process of intensifying the competencies of teachers with elements of STEM education is of practical importance, helping to develop curricula, assess the competencies of teachers, improve the quality of education and personalize learning. The main approach used in integrating STEM into the educational space is the project method. It allows you to combine various fields of knowledge, such as mathematics, natural sciences, fine arts, technology, computer science and physics, within the framework of project work. This contributes to a more complete and in-depth understanding of the world around students. Currently, STEM projects allow you to study the topics and areas of disciplines at the practical and theoretical levels.

The project method in education has a long history and is constantly evolving. It serves as an auxiliary tool to ensure the interaction between theory and practice in STEM education. The essence of the method is for students to actively engage in research activities aimed at achieving their goals and solving practical problems. Interdisciplinary projects are conducted outside the classroom under the guidance of experts from various fields of education. Depending on the nature of communication, such projects can be intra-classroom, intra-school, regional or international. Integrated lessons are being actively introduced in the Republic of Kazakhstan for the successful implementation of STEM education and compliance with new educational requirements. This allows students to gain comprehensive knowledge and skills necessary for successful adaptation in the modern world.

2. METHOD

Methods for solving scientific research problems: include analysis of existing approaches to ontological modeling, conducting experiments and research, developing and testing an ontological model, and its application to the process of intensifying the competencies of teachers with elements of STEM education, methods of data collection and analysis, surveys and interviews with teachers and education specialists [4]-[11]. The methodological and theoretical basis of the project consists of methods and models of discriminatory logics, which logics allow to describe the axioms and facts of the subject area of a distributed knowledge base. The technological basis of the work consists of methods for designing distributed information systems, distributed search algorithms and inference machines. To implement the search, the principles of text mining and semantic web are used. When solving problems of scientific research, the method of projects and ontological analysis [12]-[14], an object-based approach to software development, optimization methods, and methods of mathematical and computer modeling were used.

Currently, professions related to technology at the intersection of natural sciences are emerging. Improving the quality of learning can be achieved through the use of a STEAM approach. The introduction of STEAM education will make it easier for students to adapt when receiving higher education and a future profession. Increasing the student’s STEAM literacy will ensure relevance and competitiveness in the labor market [16], [17]. Ontologies are developed using the Protégé 4.3 ontology editor package, which is a free, open, cross-platform ontology editor and framework for building knowledge bases. The package can be accessed at http://protege.stanford.edu. The knowledge base level in the structure of a distributed information system is executed in the form of files in OWL/XML and RDF/XML formats. When carrying out the project, compliance with the principles of scientific ethics, that is, ethical management procedures, will be ensured, in particular, maintaining high standards of intellectual integrity and preventing fabrication of scientific data, falsification, plagiarism, false co-authorship, use by individual participants of collective research, data and conclusions obtained in research, without agreement with other participants. To protect intellectual property, packages of documents will be prepared to obtain a copyright certificate for a software product.

The interdisciplinary approach in the project is that the project combines various fields of knowledge and disciplines related to education, the STEM approach, pedagogy, ontology and the process of developing teacher competencies. An interdisciplinary approach allows you to attract experts from different fields to work on the project, exchange knowledge and experience, and explore the problem from different points of view. In this case, interdisciplinarity may include:

- Humanities: the study of pedagogical, psychological and sociological aspects of education, the development of teacher competencies and their interaction with students.
- Exact sciences: application of the STEM approach in developing a model and methods for developing teacher competencies.
- Information technology and ontology: development of an ontological model that will help structure and describe the process of intensifying teachers' competencies, taking into account various factors associated with teaching STEM disciplines.

The interdisciplinary approach in this project allows us to combine knowledge, methods and tools from different fields to create a comprehensive and effective approach to the development of teacher competencies using elements of STEM education. For the project "ontological modeling of the process of intensifying teachers' competencies with elements of STEM education" you can use the following software:

- Protege (https://protege.stanford.edu/) - it is a powerful and flexible platform for creating ontologies. It allows you to define concepts, connections and attributes that describe the process of intensifying the competencies of teachers, as well as use various standards and languages to formalize the ontology.
- RDFox (https://www.oxfordsemantic.tech/rfox) - is a high-performance system for working with resource description framework (RDF) and SPARQL (SPARQL protocol and RDF query language), which are standards for representing knowledge in web semantics. Using RDFox, you can store and process data describing teacher competencies and their development.
- OWLAPI (https://github.com/owlcs/owlapi) - This is a Java API for working with ontologies formalized in web ontology language (OWL). With this library you can create, modify and analyze ontologies using the functionality of the OWL language.
- Protégé editor graph (https://github.com/ncbo/protege-graph) is an extension for Protege that allows you to visualize ontologies as a graph. This can help in understanding the structure and connections between teacher competencies, as well as in conducting competency network analyses.
- JENA (https://jena.apache.org/) - is a Java framework for working with data related to semantic web technologies. It includes tools for storing, querying and processing data describing teacher competencies, and provides convenient APIs for working with data in RDF and SPARQL format.

These are just some examples of software that can be used in the project "Ontological modeling of the process of intensifying teacher competencies with elements of STEM education." The choice of specific tools depends on the requirements and preferences of the project team. The research methods are based on knowledge management, ontological engineering, service-oriented programming methods, and description logic and knowledge inference methods. They also draw on set and graph theory, parsing theory, and the concept of creating ontologies. The main goals of ontology engineering include increasing the level of information integration for management decision making, improving the efficiency of information retrieval, and enabling collaborative knowledge processing based on a single semantic description of the knowledge domain. The main goals of ontology engineering include increasing the level of information integration for management decision making, improving the efficiency of information retrieval, and enabling collaborative knowledge processing based on a single semantic description of the knowledge domain. When creating information systems, an ontological model represents an extensible and customizable knowledge system. During the study, an ontological approach was chosen to create a unified educational environment that takes into account the requirements of the labor market at the national and international levels.

When creating information systems, an ontological model represents an extensible and customizable knowledge system. During the study, an ontological approach was chosen to create a unified educational environment that takes into account the requirements of the labor market at the national and international levels. Currently, the most developed language for representing ontologies is OWL, which extends the capabilities of XML, RDF, and RDF Schema [19]-[21]. Ontology development methodology can be defined as a set of steps that must be taken when creating ontologies to ensure their clarity, consistency, extensibility, reusability and reliability. Unfortunately, there is no one standard methodology for constructing ontologies.

There is no universal approach to developing ontologies. However, in the field of ontologies, there are practices of combining different methodologies and techniques [22]. The article by Alaa *et al.* [23] proposed a methodology for constructing ontologies, presented in Figure 1, which can serve as a guide in the development of ontologies. This methodology includes several stages such as specification, conceptualization, implementation, verification and evaluation of the ontology. At the ontology specification stage, the purpose of developing the ontology and the system, service or application objects associated with it is determined. It is also necessary to describe the subject area and area of interest [24]-[28]. Data collection is also carried out during this period. Then, at the conceptualization stage, a conceptual model of the subject area is defined, as well as the ontology structure is specified and ontological relationships are defined.

Once these steps are completed, the ontology itself can be implemented using the appropriate tools. At the end of the ontology construction process, its quality must be checked and assessed. This can be achieved by involving domain experts or by quantifying the accuracy and completeness of the ontology [9]. The methodology of ontology development is a set of actions that must be performed when creating an ontology to ensure clarity, consistency, extensibility, reusability, and reliability [21]. Unfortunately, there is no universal and standard methodology for constructing ontologies [22]. Instead, practice shows that an effective approach is to combine various methodologies and approaches in the field of ontologies [23]. However, it is possible to use the general stages of the ontology development methodology proposed in [26] as a guide for creating ontologies. Figure 1 shows these phases. The ontology development process includes the following stages: specification, conceptualization, implementation, verification, and evaluation [27]. At the specification stage, it is necessary to define the goals of creating an ontology, as well as the system that it will serve, and the objects on which the ontology will be applied. It is also necessary to describe the subject area and area of interest related to ontology. An important step at this stage is data collection.

At the stage of ontology conceptualization, the conceptual model of the subject area is determined, as well as the structure of the ontology itself and ontological relations. This allows you to create a conceptual map and ensure the comparability of various elements of the ontology. After that, the ontology implementation stage takes place using the necessary tools. Here, the conceptual model is translated into a formal representation that can be used in computer systems. After completing the implementation of the ontology, its compliance with all established requirements should be checked. This includes checking the semantic accuracy, consistency, and completeness of the ontology. And the last stage is the assessment. It analyzes the effectiveness and quality of the ontology, evaluates the results achieved and the need for changes or additions. Thus, the methodology of ontology development includes clear stages that provide a systematic and structured approach to the construction of ontologies. After constructing an ontology, it must be checked and evaluated either with the help of domain experts or quantify the accuracy and completeness of the ontology [9].

Sequence of actions for ontology development. Domain analysis, defining classes, organizing class hierarchy, defining attributes and properties of classes and constraints, defining individuals and giving meaning to attributes and properties. First, you need to analyze the subject area, synthesize concepts and relationships, then select objects, attributes, relationships, and processes. Using the presented sequence of actions, we build ontologies. An ontology model of a university's distributed knowledge base was developed using the Protégé resource. This sequence is shown in Figure 1.

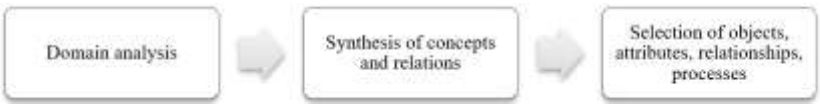

Figure 1. The sequence of actions for ontology development

Improving the quality of teaching schoolchildren can be achieved through the semantic description of knowledge about the subject area using methods of ontological engineering. The methodology of ontological engineering implies building a three-tier model of the field under study: top-tier ontologies, domain-specific ontology, and applied ontologies. The algorithm of ontological engineering is shown in Figure 2.

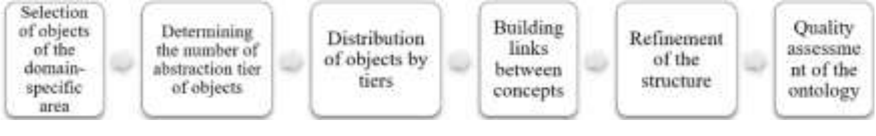

Figure 2. The algorithm of ontological engineering

Classes describing the subject have been created. Based on the object structure, an ontological model is built in the Protégé editor. It can then be exported to XML or another format.

3. RESULTS OF A COMPUTER EXPERIMENT

The construction of an ontology begins with the creation of an ontological model of the subject area. To do this, you need to define the base classes and the relationships between them. This is necessary because we are developing a school ontology that allows us to show the process of intensifying teacher competencies with the integration of STEM education [27], [28].

Based on the ontological engineering carried out, an ontology was built for the process of intensifying the competencies of teachers. This ontology includes the following classes:

- Course;
- Learning outcomes (Subclasses: skills, abilities, knowledge, and competencies);
- E-learning tools (Subclasses: databases, technical means, information technologies, and information systems);
- Participants in educational relations (Subclasses: lecturer, teacher, management, tutor, and teacher);
- Lesson plan (Subclasses: teacher actions, homework, assessment, summarizing, section, resources, reflection, lesson topic, and learning objectives in accordance with the curriculum);
- Regulatory framework (Subclasses: standards, regulatory documents of education, and laws of the Republic of Kazakhstan).

An ontological model of the process of advanced training for teachers with the integration of STEM education was built. The hierarchy of classes of this ontology is presented in Figure 3.

Figure 3. Hierarchy of the ontological model of the teacher training process

As an example, consider the advanced training course “machine learning”. Figure 4 shows SubClass - course_name, members (individuals) - course topics. Members (individuals) of the course “machine learning”: “getting a certificate after being employed at the training center”, “machine learning”, “studying a new material”, “the correctness of the answer to the tasks”, “there is also_artificial intelligence?_What is this_Artificial intelligence?_What is this Machine learning?”, “they assimilate a new material”, “what did you feel when you completed the tasks?_What did you feel about working as a trainer?”, “Find_out_what_is_this_machine_learning”, and “learning_response_questions”.

Figure 4. Advanced training course “machine learning”

To create a connection between “tutor” and “course”, we create a property of the object has_leads_the_course (teaches the course), as shown in Figure 5. Using this application window, properties of objects are created. Figure 6 shows the connections and relationships of classes and individuals of the ontology for the advanced training course “machine learning”. The has_leads_the_course object property is shown in red. Figure 6 shows the members(individuals) of the course “machine learning”.

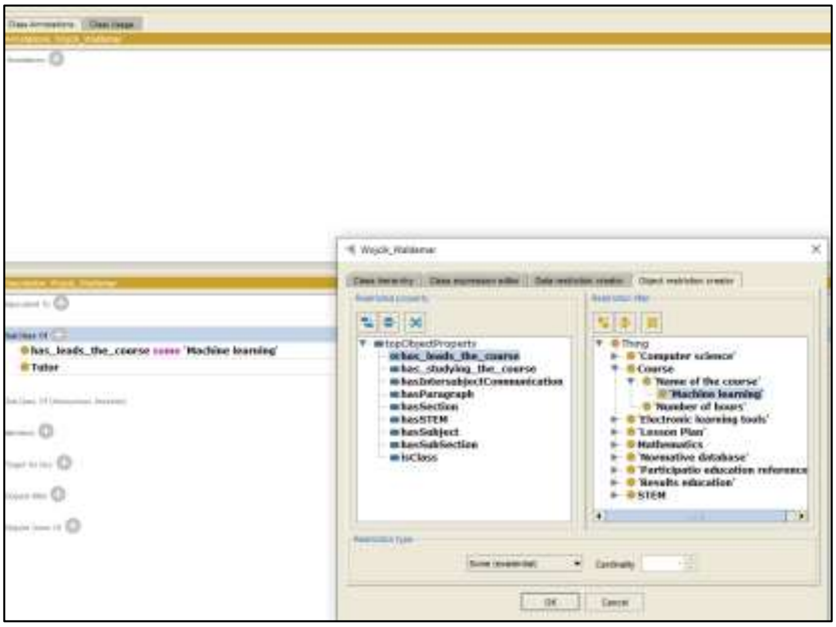

Figure 5. Has_leads_the_course object property

To create a connection between “teacher”, taking a course and “course”, we create a property of the object has_studying_the_course (studying the course), as shown in Figure 7. The properties of an object describe the connections between two individuals. We can consider these individuals to belong to a class of individuals in which everyone has a has_studying_the_course relationship.

Figure 8 shows the connections and relationships of classes and individuals of the ontology for the advanced training course “machine learning”. The object property has_studying_the_course is shown in red. The connections of the tutor - waldemar wojcik with the name of the course -machine learning class and its individuals are shown. The connection of educator – Bazarova Madina Zhomartovna with the name of the course class -machine leaning is shown.

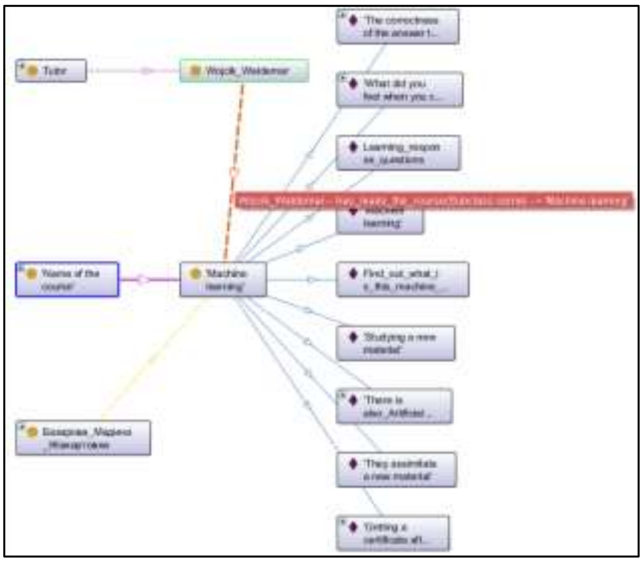

Figure 6. Fragment of the ontology displaying the tutor-course relationship

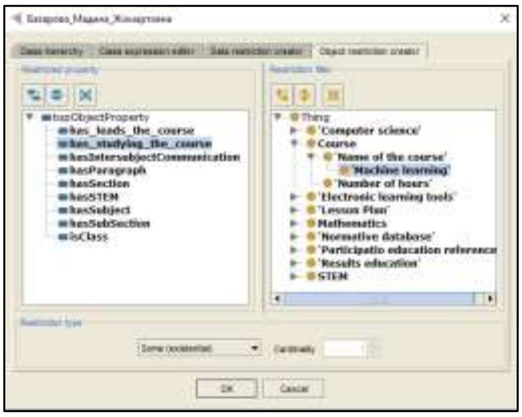

Figure 7. Property of the object has_studying_the_course

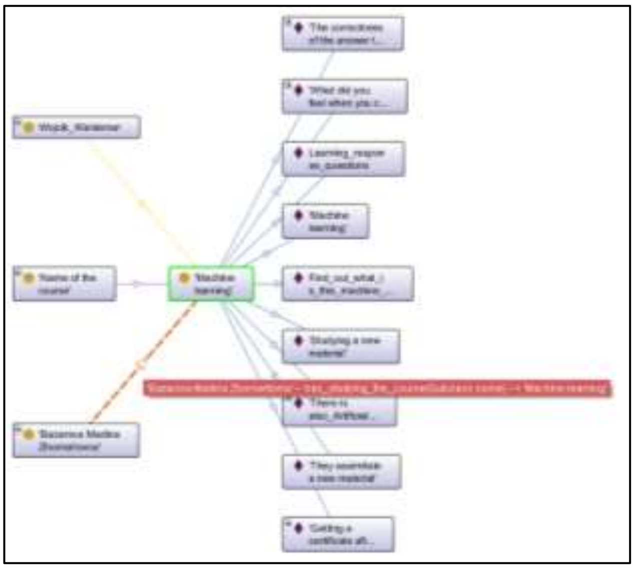

Figure 8. Fragment of the ontology displaying the teacher-course relationship

OntoGraf supports various layouts to automatically organize the structure of your ontology. Various relationships are supported: subclass, individual, domain/range object properties, and equivalence. Links and node types can be filtered to help you create the desired view. A fragment of the ontological model of the process of advanced training of teachers with the integration of STEM education, shown using the OntoGraf visualization tool is presented in Figure 9.

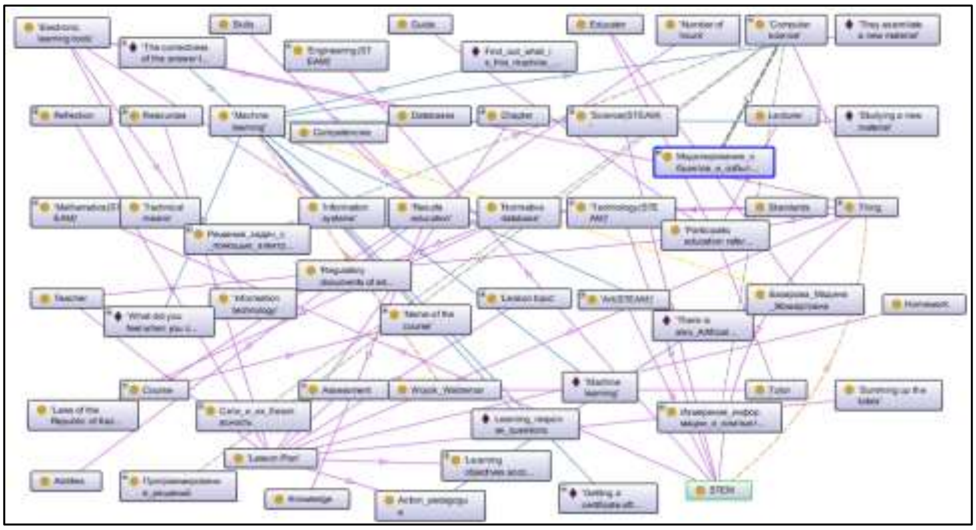

Figure 9. Fragment of the ontological model of the process of advanced training of teachers with the integration of STEM education

“An ontological model of the process of intensifying teachers” competencies with the integration of STEM education” will help develop curricula, assess teachers’ competencies, improve the quality of education and personalize learning while improving the qualifications of teachers.

4. CONCLUSION

Application of the results of the study “ontological model of the process of intensifying the competencies of teachers” in educational organizations and universities of the Republic of Kazakhstan will provide online support for the educational process, organization of collaboration and communication between students and teachers. Ontological modeling is a methodology that allows you to organize and systematize knowledge in a particular field. In the context of STEM education, the development of ontological models helps to structure and integrate knowledge and concepts from various sciences for more effective learning. Application of ontological engineering and the STEAM approach in the process of intensifying the competencies of teachers. Thus, ontological modeling of the process of intensifying competencies will help develop curricula, assess the competencies of teachers, improve the quality of education and personalize learning while improving the qualifications of teachers. This approach will allow us to further improve and apply the data of the ontological model in the process of intensifying the competencies of teachers. By populating the knowledge base, it becomes possible to identify relationships between advanced training programs. The use of ontological engineering methods will improve the quality of teacher education through the semantic description of knowledge in the subject area and the use of interdisciplinary and STEM approaches in the educational process. An ontological model of the process of intensifying teachers’ competencies with the integration of STEM education has been developed and was built using the Protégé 4 editor. It contains the necessary classes, relationships, properties and individuals of the process of intensifying teachers’ competencies. Queries to this ontology have been completed. A hierarchy of classes and fragments of the constructed ontology was presented. The introduction of STEM elements into the program for intensifying teacher competencies will facilitate the adaptation of teachers to further education and obtaining an integrated profession. Having studied the experiences of countries that are actively working with STEM technology, we can conclude that this technology has great potential for developing key 4K skills (creativity, teamwork, critical thinking, and communication) that are integral to today’s students. However, when introducing this technology, it is necessary to keep in mind the goals of education and give importance to the mastery of each competency by students. The results obtained will be useful to educational organizations and educational and scientific bodies of the Republic of Kazakhstan. The ontological model of the process of intensifying teachers' competencies with the integration of STEM education was built in the article using a manual method; in the future, it is planned to fill the ontology knowledge base using a semi-automatic method. The authors of the article conducted several studies on the topic of ontological modeling in the field of education. Several ontologies have been created: the ontology of interdisciplinary relations between mathematics and computer science, the ontology of STEM education, and the ontology of knowledge transfer at universities. These ontologies will be further integrated with each other to create a unified system of ontologies for the field of education.

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