VI International Forum on Teacher Education

Pedagogical Model for Creating Individual Learning Paths Based on Educational Maps

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Abstract

The problem of the structure of the learning environment, its properties and the technological basis for its creation is extremely urgent at present. This issue is addressed in numerous studies. An essential role in such an environment is played by individual learning paths. The question of developing a pedagogical model for creating individual learning paths based on educational maps, to which this study is devoted, remains open.

The purpose of this study is to develop a pedagogical model for creating individual learning paths based on educational maps. The leading approach to researching the problem is based on ideas of project-based and student-centered active learning. The developed pedagogical model for creating individual learning paths on the basis of educational maps includes four main blocks - target, content, procedural and algorithmic and the block of implementation and evaluation. The target block consists of goals, requirements, methodological approaches and guidelines for creating individual learning paths based on educational maps. The goal is to increase the student's activity and independence, support positive motivation, and individualize the learning process. As leading principles, we define adaptability, projectivity, and subjectivity. The content block includes a description of the structure of educational maps, technology for creating individual learning paths based on those maps. The procedural and algorithmic block includes a description of the scenarios practical implementation of individual learning paths based on educational maps. The block of implementation and evaluation contains a description of the methods, criteria and the corresponding performance indicators for creating individual learning paths based on educational maps.

Keywords: individual learning path, educational map, individual educational map, distance learning, project-based learning.

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Introduction

The problem of the structure of the educational environment, its properties and the technological basis of its creation is extremely relevant at present. The problem is addressed in numerous studies (Annansingh, 2019; Blažič & Blažič, 2020; Boyarinov, 2018, 2019; Cañas et al., 2003; De Cohen & Clewell, 2007; Emelchenkov et al., 2011; Iatrellis et al., 2019; Miller, 2004; Schwendimann, 2014). A significant role in the framework of such an environment is played by individual learning paths, as an instrument of personalization of the learning process. This actualizes the problem of generalizing this concept. As one of the possible solutions to this problem, we proposed the concept of "interactive educational map" (Boyarinov, 2018), interconnected with the concepts of "educational map" (De Cohen & Clewell, 2007; Miller, 2004), "concept map" (Cañas et al., 2003), "knowledge integration map" (Schwendimann, 2014). In the framework of this approach, the educational map can be considered as an information environment in which the process of creating individual learning paths of students takes place. This issue is particularly relevant in the context of distance learning, in which any types of information interactions, both between the student and the teacher, and between students, are mediated by the learning environment.

Purpose and objectives of the study

The purpose of this study is to build a pedagogical model for creating individual educational trajectories based on educational maps.

Literature review

The concept of an individual learning path is very common in modern science. As a rule, its consideration is caused by the need to improve the quality of learning. It arises as a tool for personalizing the educational process. As noted by Iatrellis, Kameas and Fitsilis (2019, p. 781), "One of the main challenges to be confronted by Higher Educational Institutions (HEI), so as to increase quality, is the provision of personalized education services in a wide range of educational settings". The learning path can be defined as "route, taken by an individual learner through a range of educational activities" (Iatrellis et al., 2019, p. 782). At the same time, a number of synonymous terms (learning pathway, learning route, learnflow, learning network) are used to designate it. Note that the definition given by Janssen, Hermans, Berlanga and Koper, and cited by Iatrellis et al. (2019) in their paper, already contains an indication of individualization and personalization. Onward we will use the term "individual learning path" to further emphasize this fact. Returning to the work of Iatrellis et al. (2019), it is necessary to note the original approach to creating an individual learning path proposed by these authors. They based this process on a

continuous analysis of the student's current academic activity, and continuous forecasting of the next learning activities within the curriculum. According to their concept, the construction of an individual learning path is a continuous selection of components (sub-processes) from the existing set defined by the curriculum: "learning pathway is being composed as the platform selects and combines sub-processes stored in a repository" (Iatrellis et al., 2019, p. 786). The work of Iatrellis et al. (2019) is a vivid example of a process-oriented approach to the creation of learning paths.

A different approach is possible. It is based not on the processes, but on the learning content. The basis of this approach is the concept of "educational map" and related concepts.

The concept of "educational map" (De Cohen & Clewell, 2007; Miller, 2004) is widespread in modern pedagogy. There are a number of related concepts, which primarily include such concepts as "knowledge integration map" (Schwendimann, 2014), "concept map" (Cañas et al., 2003), "interactive educational map" (Boyarinov, 2018). According to the approach of De Cohen and Clewell (2015, p. 1), the educational map is a combination of "intermediate goals, objectives, ways to achieve them in the framework of solving the generalized learning problem". In the framework of this approach, the authors implicitly note the relationship of the educational map and the learning path. Miller indicates the presence in the learning map of information about all kinds of potential alternatives for the learning process of a particular student and his/her personal development (Miller, 2004, p. 1). As noted by Cañas et al. (2003, p. 5), a concept map is a form of graphical representation of knowledge. Accordingly, the basic structural elements of a concept map include concepts and the relationship between concepts. A number of authors developed an approach based on the use of graph theory in pedagogy, while the elements of knowledge (including concepts, but not reducible to them) and the relationship between elements of knowledge (Boyarinov, 2018; Emelchenkov et al., 2011).

Significant development in the theory of educational maps was introduced by Schwendimann by his concept of "knowledge integration map". This concept makes it possible to improve quantitative methods for analyzing the information contained in a map (Schwendimann, 2014, p. 18). In such maps, concepts and the relationships between concepts are assigned certain weights, which provides a tool for storing numerical information. Yin et al. (2005, p. 167) indicated that the concept map is the result of a process of measuring the structure of knowledge. It is possible to quantify concepts, levels of the hierarchy of concepts, relationships between concepts, sentences (ternary structures of the form "concept - relationship between concepts - concept") (Cañas et al., 2003, p. 5; Yin et al., 2005, p. 166). Thus, it should be noted that to date, a significant amount of information has been accumulated in pedagogical research, which allows us to construct concept maps, educational maps and process the quantitative information stored in

them. Educational maps are currently being reviewed in conjunction with the digital learning environment. Annansingh (2019, p. 3), for example, directly included concept maps as an organic element in this environment. Since the creating of individual learning paths occurs within the framework of the learning environment, the question naturally arises of using the information contained in the educational map when creating these paths. The issue of developing a pedagogical model for creating individual educational paths based on educational maps is still open. The purpose of this study is to develop a pedagogical model for creating individual learning paths based on educational maps.

Methodology

The following complex methods were used in the study: the study and analysis of scientific and pedagogical literature, a comparative analysis of the experience of using educational maps and creating individual learning paths, sociological surveys and interviews of students and teachers. The leading theoretical approach to researching the problem were ideas of project-based and student-centered active learning.

The study took place from September 3, 2016 to December 31, 2019 (Smolensk State University) with the participation of 54 master students of educational program "Teacher Education" ("Educational Management" program).

The training course created in accordance with the developed theoretical principles was used in the organization of the educational activities of graduate students. During the study of reflection by graduate students on the experience of designing and implementing individual educational routes on the basis of educational maps, qualitative results were obtained that are consistent with the developed theoretical principles. They noted an increase in the level of activity and independence of students, the development of positive motivation.

Results

The developed pedagogical model for creating individual educational paths on the basis of educational maps includes four main blocks - target, content, procedural and algorithmic, and block of implementation and evaluation.

I. Target block

The target block consists of goals, requirements, methodological approaches and principles for creating individual learning paths based on educational maps. The goal is to increase the student's activity and

independence, support positive motivation, individualize the learning process, and support distance learning technologies.

A necessary condition for achieving this goal is to fulfill the following requirements:

1) the formation of an information system that reflects the individual psychological characteristics of students, their values, motivation and requests for the system of education;

2) the creation of models of educational content to be studied in the process of movement along an individual learning path, correlated with the particular qualities of the student;

3) providing the student with the opportunity to master educational content on the basis of project activities; at the same time, educational projects should have a predominantly interdisciplinary nature and their content should reflect the personal values of the student's attitude;

4) providing the student with the possibility of continuous reflection of the movement process along an individual learning path, the ability to design and predict the further course of this process;

5) the creation of a system that provides continuous collection and analysis of information about the individual educational achievements of the student in real time. As leading principles, we consider the principles of subjectivity, adaptability and projectivity.

1. The principle of subjectivity assumes that the student's personality with all its inherent individual characteristics is the central element of the proposed pedagogical model and determines the sequence of development of educational content, forms and methods of learning. According to Iatrellis et al. (2019, p. 781), "each student is a unique case" and this fact should be fully and comprehensively reflected in the structure of his/her educational activity in the process of moving along an individual learning path.

2. The principle of adaptability, which naturally follows from the principle of subjectivity, presupposes the availability of tools that provide changes in the content, scenarios and algorithms for the functioning of the learning environment. Such tools should provide reflection in the projected educational activity of both the individual characteristics of the student and the characteristics of the specific educational content that he/she must master. Thus, adaptability is considered by us in two aspects – as adaptability in relation to a student and as adaptability in relation to educational content.

3. The principle of projectivity assumes the leading role of the project-based learning in the course of movement of the student along an individual learning path. The learning project as an effective form of

development of the student's activity and independence, supporting his/her positive motivation is the main structural unit of the individual learning path.

II. Content block

The content block includes a description of the structure of educational maps, technology for creating individual learning paths based on them.

The educational map in its traditional sense is a formalized representation of learning content. The two main classes of objects that are reflected on the map are concepts and the relationship between them. The initial set of concepts is quite strictly determined by the educational content. The relationship between the concepts is due to two groups of factors. On the one hand, this is the structure and logic of the educational content. In this sense, the relations between the concepts are objective in relation to the single student. On the other hand, these are the individual characteristics of the student – the current structure of knowledge he/she has, the characteristics of the cognitive sphere, the dominant type of thinking (visual-figurative or abstract-logical). In this sense, relations between concepts are influenced by the personality of the student. Accordingly, we propose to call the educational map, which reflects the personality of the student, an individual educational map. From a formal point of view, an individual educational map is a superposition of two theoretical models – a model of educational content (reflecting all causal and logical connections between its elements and possible ways of learning) and a student's model (reflecting his/her personal characteristics, requests and attitudes).

Objects of each class can optionally have attributes. As a rule, attribute values are natural numbers, while other options are possible. A classic example of an attribute is weight (naturally a number), attributed to the connection between concepts and quantitatively describing the degree of formation of this connection for a given student at a given moment of time (Boyarinov, 2018; Emelchenkov et al., 2011). Attributes are the main tool for individualizing an educational map. Accordingly, the analysis of attributes is a key tool for implementing the principles of subjectivity and adaptability in the creation of individual learning paths.

We suppose that the creation of an individual learning path is a process consisting of four main stages.

1. Construction of a formal model of educational content. Such a model should be deliberately redundant in relation to all possible requests of students. The information basis for constructing such a model is the state educational standard (if any) and the entire set of relevant teaching aids corresponding to it. Substantially, this stage is a formal modeling of this subject area. As the main modeling tool, we consider the language of graph theory (Boyarinov, 2018; Emelchenkov et al., 2011).

2. Building an individual educational map. At this stage, it is necessary to determine and describe the individual characteristics of the student, which will be taken into account when building an individual educational route. Some of these characteristics (such as learning objectives, the desirability of attracting scientific information from some related fields of knowledge, etc.) can be consciously indicated by the students themselves. Other characteristics (such as the current structure of the student's knowledge, cognitive features, the dominant type of thinking, etc.) can be obtained as a result of the student's psychological and pedagogical research. Substantially, this stage is a study and a formalized description of the individual characteristics of the student and the construction of an individual educational map as a superposition of the formal model of educational content and the student model.

3. Designing an individual learning path based on an individual educational map. Substantially, this stage is a search for the shortest path on the map that connects the initial position (reflecting the current competencies of the student at the time the learning begins) and the learning objectives. In the case where the shortest path is not the only one, the choice of a specific path from the spectrum of possible is provided to the student. Thus, an individual educational map is the information basis of the process of creating an individual learning path, as it contains all the information necessary for this. In this case, the process itself is substantially algorithmizable. Algorithms for finding the shortest paths on the graphs are well known and have been used in pedagogy for a long time (Emelchenkov et al., 2011).

4. The educational process itself is the process of promoting a student along an individual learning path. This process should be accompanied by continuous reflection by the student. Accordingly, the educational environment should provide him/her with information about his/her current educational achievements, values and the dynamics of changes in the parameters characterizing the course of the educational process. Substantially, this stage is an educational process based on project learning, accompanied by continuous pedagogical monitoring.

III. Procedural and algorithmic block

The procedural and algorithmic block includes a description of scenarios for the practical implementation of individual learning paths based on educational maps.

As a basis for identifying learning process scenarios based on individual learning paths, we propose the approach of Annansingh (2019). He identified two types of scenarios – synchronous and asynchronous (Annansingh, 2019, p. 3). The implementation of the asynchronous scenario does not require the organization of interaction between the student and all components of the educational environment (which include educational content, educational material, teachers and other students) in real time. Typical

examples of technological tools that can be used are electronic bulletin boards, forums, and email. In the framework of the asynchronous scenario, the educational map and individual learning path are a source of instructional instructions for the student on the sequence of mastering the elements of educational content and forms of educational activity in the development process. At the same time, the teacher receives information about the course of the learning process and can, if necessary, adjust its course.

The main disadvantage of the asynchronous scenario is the lack of operational feedback of the student with the teacher and the relatively low level of social interactions (both between students and between the student and teacher) (Annansingh, 2019, p. 4). The study (Blažič & Blažič, 2020, p. 272) emphasizes the key role of social interactions in solving the problem of successful adaptation of a student in the information educational environment. Deep and comprehensive involvement of students in the educational process is impossible without the instructive support that the student can receive from the teacher and other students (within collective forms of training). Accordingly, a synchronous scenario is necessary. Its main feature is that all interactions between the subjects of the educational process occur in real time. The main technological means providing such interaction are certain Internet information services (audio and video conferences, chats, application sharing, etc.). In the framework of the synchronous scenario, the educational map and individual learning path are primarily a tool for organizing social interactions (of a teacher with a student and students among themselves). They contain a complete description of the learning process for students. This allows, in particular, to synchronize certain stages of the educational activity of various students, ensuring the implementation of group projects.

The main difficulty in the synchronous scenario is the problems with the allocation of time resources for various types of educational activities (Annansingh, 2019, p. 4). The educational map and individual learning path contain all the information necessary for calculating the time to complete educational activities. They serve as a tool for visualizing the student's progress on educational content. Thus, they provide the student with a guideline for proper time management in the learning process.

IV. Block of implementation and evaluation

The block of implementation and evaluation of the pedagogical model developed by us contains a description of the methods, criteria and the corresponding indicators of the effectiveness of using individual learning paths based on educational maps in the educational process.

The leading method for evaluating effectiveness is continuous pedagogical monitoring (Boyarinov, 2018, 44-46).

We propose a system of four criteria (and corresponding indicators) for the effectiveness of the application of individual learning paths in the educational process based on educational maps.

1. Reflection of the individual psychological characteristics of the student, his/her value attitudes, characteristics of motivation and requests to the system of education. An indicator of effectiveness according to this criterion is the level of subjective assessment by students of the degree of conformity of the learning process to its requests, expectations, and features.

2. Implementation of learning projects. Performance indicators for this criterion are the proportion of learning projects in relation to the total volume of educational activities and the level of complexity of current learning projects. The complexity of the learning project is manifested, in particular, in the number of interdisciplinary connections in its content and in the intensity and complexity of the interactions between its performers.

3. Implement feedback. We consider feedback on two levels: student-teacher and student-student

The indicator of effectiveness for the first level of this criterion is the number of student appeals to the teacher on educational issues and the subjective level of student satisfaction with this interaction.

The performance indicator for the second level of this criterion is the share of collective projects of the total number of learning projects implemented by students and the total number of co-executors in these projects.

4. Academic results. Performance indicators for this criterion are the current level of student's academic achievements and the dynamics of changes in this level throughout the entire period of advancement along an individual learning path.

In the experimental part of our research, master students both created individual learning paths (that is, acted as teachers), and underwent learning on them (that is, acted as students). In the course of the study of reflection, experiment participants were asked the following questions:

- What is the leading factor in relation to ensuring high quality of learning?

38 respondents (70%) called "taking into account the individual characteristics of the student"; 9 respondents (17%) called "ensuring continuous interaction with a tutor"; 7 respondents (13%) called "organization of collective forms of work".

- Does learning in the context of the application of individual learning path on the basis of educational maps enhance the interaction of the student with other students?

33 respondents (61%) answered positively; the rest answered in the negative.

- What stage of creating an individual learning path on the basis of educational maps is the most time-consuming and most difficult?

33 respondents (61%) named the construction of an individual educational map; 21 respondents (39%) called the construction of a formal model of educational content.

- What is the proportion of synchronous and asynchronous scenarios in the learning process using individual learning paths based on educational maps? All survey participants were asked to rank synchronous and asynchronous scripts on a 10-point scale, evaluating their relative importance. The ranking results, averaged by the number of respondents and rounded to tenths: 7.4 - synchronous scenario, 4.8 - asynchronous scenario.

- Is it possible to consider the project method as monotechnology, a non-alternative form of organization of the educational process?

19 respondents (35%) answered positively; the rest answered in the negative.

- Should learning projects have an exclusively interdisciplinary nature?

23 respondents (43%) answered positively; the rest answered in the negative.

- Does the use of the project-based learning contribute to the development of student independence activity?

33 respondents (61%) answered positively; the rest answered in the negative.

- Does continuous reflection of the process of movement along the individual learning path improve the quality of learning?

51 respondents (94%) answered positively; the rest answered in the negative.

All survey participants noted an increase in the level of activity and independence of students, the development of positive motivation.

In general, we can conclude about a positive attitude towards the implemented pedagogical model. According to the results of reflection, the project-based learning approach causes the greatest doubts. Student-centric approach is accepted with the greatest agreement and appear to be the most effective.

Discussions

The results discussed in the previous section show that educational maps in their modern interpretation have significant potential in relation to the creation of individual learning paths. Moreover, the most significant is the quantitative information contained in the educational maps. Individualized educational maps reflecting personal attitudes, individual psychological characteristics, goals and motivation of students form a complete information environment in which it is possible to build individual learning paths. On the other hand, the principles of creating such paths need further reflection and improvement. While the importance of collective forms of educational activity in the conditions of a virtual educational environment is recognized by most researchers, the question of the role of the learning projects requires clarification. What is the optimal proportion of learning projects in relation to other forms of educational activity? Is it possible to consider a collective learning project as the undoubtedly dominant form of collective learning? We tend to give a positive answer to the last question, but we are fully aware of the need for further experimental verification. The student-centric approach to the organization of the educational process seems uncontested in modern conditions. Its effectiveness is confirmed by numerous studies. Actual is the problem of choosing the forms of implementation of this approach. Such a form in our study is an individual educational map. In the framework of the approach adopted by us, it is that is the informational basis for the process of creating an individual learning path, since it contains all the information necessary for this.

Conclusion

The implementation of the principles of adaptability, projectivity, and subjectivity in the design of educational maps and the creation of individual learning paths based on them helps to increase the level of activity and independence of the student, supporting positive motivation, individualization of the educational process, including in the context of distance learning. Moreover, at various stages of the educational process, educational maps implement various didactic functions. The experience gained in the framework of this study allows us to clarify the concept of interactive educational maps that we introduced earlier (Boyarinov, 2018): by an interactive educational map we mean the space of all possible individual learning paths within the framework of given educational content, reflecting the structure and logic of this content and providing student multiple interaction with the learning environment.

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