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Transform a Physics Course in Middle School through Personalized Learning and Digital Platform

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Abstract

The article discusses the possibilities of forming and evaluating subject and meta-subject outcomes provided by the use of personalized learning and a digital platform. It demonstrates how the concept and structure of the platform influence the content and effectiveness of the educational course. Examples describe the use of learning analytics for assessing educational outcomes based on the analysis of data collected by the digital platform. The personalized learning tools aimed at formation of subject and meta-subject outcomes. The summary gives an overview of the results of the two years of experience in teaching physics at school with the use of the digital platform.

Keywords: digital platform, personalized learning, competency-based education, learning ability, regulatory universal learning skills, evaluation of meta-subject outcomes, digital footprint.

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Introduction

One of the main target goals of the Federal State Educational Standard for the basic general education in the Russian Federation is readiness for constant education and learning ability (Federal State Educational Standard, 2010). To reach this ability a student must be purposefully trained throughout the entire school period. General schools do not do this: from 1st to 11th grade a student is a dependent: he receives assignments from teachers and must perform them. He also receives an assessment of his performance from the teachers. In addition, the emphasis on subject results completely displaces universal learning skills in the teacher's minds, which are not subject to external evaluation: All-Russian test works contain only subject results, and regional test works, for example, conducted by the Moscow Education Quality Center, do not evaluate regulatory universal learning skills during evaluation of meta-subject skills, as evidenced by the codifiers of meta-subject skills of evaluating works published on the website of the Center. At the same time, regulatory universal learning skills are an important basis for learning ability.

The Standard considers the following abilities as regulatory universal learning skills:

- to set learning goals;

- to independently plan ways to achieve goals;

- to control personal activities;

- to evaluate the correct performance of a learning task;

- self-control, self-assessment, decision-making and making conscious choices in learning and cognitive actions.

This list of skills describes the student as a leading person (“actor”, “agent”) in the educational process. In report published at Harvard University in October 2015 student agency was defined as “the capacity and propensity to take purposeful initiative – the opposite of helplessness” (Ferguson, 2015, p. 1). John Hattie (2009) summarizes the results of his greatest study on the effective teaching and learning in the following words: “the biggest effects on student learning occur when … students become their own teachers” (p. 22). He highlights that it means self-regulatory skills: self-monitoring, self-evaluation, self-assessment and self-teaching.

In modern education, personalization is considered as one of effective ways to put a student in such position: the opportunity for everyone to learn at their own pace, to choose the complexity level and a way to master the content (Marzano, 2017). This approach requires a serious transformation of the educational process and new pedagogical tools.

Nowadays, these are primarily digital tools providing access to information, collection and analysis of data on the educational process, automation of various processes and prompt feedback. Can they work for meta-subject outcomes (e.g., regulatory universal learning skills) and, moreover, help in their evaluation? Our study considers these questions.

Purpose and objectives of the study

This study's goal is to find effective ways and digital tools to personalize the educational process in secondary schools in order to create the basis for learning.

Literature review

The results of longitudinal study published by Zuckerman and Wenger (2010) describe the learning ability's characteristics, which they define by the term "learning independence", giving it the following definition: "The learning ability, or learning independence, is a person's ability (1) to find what exactly knowledge and skills he lacks to solve a given problem and (2) to find the missing knowledge and master the missing skills" (p. 10). Researchers note the learning ability's important characteristics: power of reasoning, proactive attitude, independence. The authors argue that the learning ability is formed by special learning activities. At the same time, the researchers point out the critical importance of supporting children's initiative. The difficulty in implementing this approach in public schools is that, in addition to changing the education content, it requires a high level of instructional skills and a high degree of individualization in teaching.

For the competency-based education learning outcomes are the main part of each course. Students are assessed on competencies – an explicit, measurable, transferable learning outcome (Marzano, 2017). It creates the basis for a content renewal, as well as for the learning ability developing, because students are guided in learning by these goals. But a competency-based education can also be realized in a school where students are dependent learners.

In addition to competency-based education personalized learning could provide a student's position as active learner. Personalized learning, defined by Marzano (2017), is an education driven by each student’s unique needs and often implies teachers tailoring their instruction, assessment, and even content to individual students. He believes that personalized learning in integration with a competency-based education creates the necessary conditions for the learning skills building. Marzano (2017) calls this approach personalized competency-based education.

Although personalized learning can be implemented without digital tools, different digital platforms are the main educational trend. Today's most massive project for personalized competence-based education using digital platforms is Summit Learning based on the learning ability and aimed to prepare students for entry and successful study at universities (Uvarov, 2018).

A digital platform as a personalization tool records data on each student's learning process, which provides monitoring, feedback, and application of learning analytics - methods of measurement, storage, analysis and presentation of data on students and the educational environment, in order to understand and optimize learning processes and conditions (Lodge et al., 2018), which allows to design learning ability's indicators and evaluate efficiency of a personalized approach's tools.

In this article the term learning ability will be used to signify a group of regulatory universal learning skills formulated in the Standard.

Methodology

Action Research is used as the main method based on taking actions and doing research (Kemmis & McTaggart, 2014). The methodology was chosen due to the school life real problems and the need for the study's practical result conducted by the team of teachers. One of the main stages of this methodology was the development of a new physics course, based on a competency-based approach, using a digital platform and focused on the personalized learning.

The target effects planned in this study are: personalized learning, learning ability and learning success.

The study’s separate task is to develop tools to assess the learning ability based on analytical work with data accumulated on the digital platform - "digital footprint" in the terminology of the developers of the National Program "Digital Economy of the Russian Federation” (Uvarov et al., 2019, p. 69). Methods of learning analytics were used in the design of evaluation tools (Lodge et al., 2018).

The study was conducted in private “Khoroshevskaya School” (Khoroskola) between April 2018 and April 2020 on a sample of 79 students in grades 6-7. Physics (7th grade) and its preliminary study in the Natural Science course (6th grade) were chosen as a basic subject. The main tool for personalization was a digital platform in two versions: “Empower Learning” (based on Marzano's pedagogical concept) and “School Digital Platform” (developed with the support of Sberbank). The platform was used as a shell for original educational content developed and tested by Khoroshkola's team of methodologists and teachers and based on Khoroshkola's pedagogical concept - personalized competence-based education.

The development of educational content applied backward design methodology (Wiggins & McTighe, 2005), which was the basis for formative and summative assessments combined into units integrating content by use of Big Idea.

The proficiency scale developed by Marzano Institute was used for assessing learning outcomes (Marzano, 2017). The learning outcomes description packed in the scales was specifically created as part of the study and was examined by Marzano Institute in 2018. The subject and meta-subject outcomes were monitored during learning process in Khoroshkola based on the personalized approach.

Results

1. The study's main result is a deep transformation of course content during digitalization and transfer to a digital platform. The two-year work resulted in the creation of a full-fledged course which can be considered as a working model of the digital learning and methodological complex (Uvarov et al., 2019).

Changes in the content were made by the concept and structure of Sberbank's digital platform (Kazakova, 2019):

- sets the competency-based frame the content (all educational content is based on learning outcomes, which determine the content structure and the individual learning plan for a student);

- requires a key question and Big Idea for each unit;

- determines the variability and the choice of assessments for students;

- ensures students' independence in their studies, as well as learning outcomes' transparency.

In this regard, the following changes have been made in the 7th grade physics course (in comparison with the traditional one):

- The standard physics curriculum for 7^{th} grade was grouped into 9 units with content based on Big Ideas.

- The backward design was used for each unit: first learning outcomes were formulated, then performance tasks were developed and finally the learning content was selected and developed. All learning outcomes in physics listed in the Standard were distributed to units, each outcome was ranked by the levels of cognitive complexity corresponding to the proficiency scale's levels (preliminary, basic, standard, advanced; numbered accordingly: 1.0, 2.0, 3.0, 4.0). Each unit has its own proficiency scale for learning outcomes.

- All assessments were created in relation to the learning outcomes.

- Special inter-subject tasks developing meta-subject skills have appeared in the course content.

- Learning content has been converted: assessments become the only units of learning content – these include all the subject information.

- Assessments language was made appropriate for independent work,

- The content was enriched with a large number of an open tasks offering solutions to complex problems.

2. The study's second result was identifying digital platform's parameters suitable for evaluation of learning ability. A number of indicators, algorithms for their calculation and visualization to monitor subject and meta-subject outcomes and correct the learning process was designed as a result of the theoretical comparative analysis of personalized learning's key parameters and data on the learning process on the digital platform.

Indicators calculated on the basis of data collected by the digital platform:

– Learning Performance Indicator (cumulative assessment of subject results): determines learning outcomes - the ratio of learning outcomes achieved by student in relation to planned ones. Calculation algorithm based on data on the digital platform: sums up the levels achieved on each scale (unit) for all scales during the learning period (level of achievement recorded on the platform is between 0 and 4.0). The amount received is divided by the planned total level of all scales for the learning period (usually level 3.0). This indicator displays the student achievement.

– Learning pace indicator: the time difference between the planned and actual completion of the learning units (at level 3.0 of the grading scale). Calculation algorithm: calculated time difference between the planned and actual dates (separately for the beginning and for the end) of each module.

– Choice indicator: students completing optional tasks. Calculation algorithm: calculated ratio of the number of tasks successfully completed to the total number of tasks successfully completed in each module.

– Learning awareness ratio: student's understanding of the learning objectives, the sequence of their achievement, and the performance criteria - calculated percentage of the required tasks completed in each unit.

– Student's learning activity indicator. Calculated ratio of the number of tasks completed to the total number of tasks in each unit.

– Student efficiency indicator: ratio of the number of tasks successfully completed from the first attempt to the total number of tasks successfully completed.

Student performance indicator was tested during 2 years in Khoroshkola and currently is used as the basis for the final grades. It is planned to evaluate its correlation with other indicators just recently started being tested as a continuation of the study.

3. The study's third result was a set of tools for personalization and building learning ability. The set was developed and selected step-by-step.

On the first step, while personalizing the school culture (May 2018, 7th grade), class communities protested against applying personalized learning tools by sacrificing the time for mastering a subject. Students were not used to key competencies. As a result, the planned amount of time for cooperation in a classroom was reduced.

The next step (May-September 2018) was to develop tools for assessing educational outcomes (proficiency scales). They were supposed to contain all subject outcomes mentioned in the Standard distributed by levels of complexity. In the first year of applying proficiency scales, it was found that students had difficulty to understand the language of the learning goals and they did not use it in their studies. As a result, all educational outcomes were rewritten in students' language. By then students got opportunity to use personal learning plan for each unit and reflexive self-assessment of the learning goals achieved. In addition to these tools developing the learning ability, marking of questions in performance task was added to assessment criteria. The use of these tools increased the number of students spending extra time on the subject (including those having additional hours in their personal learning plans).

Learning strategies changed in the process of mastering personalized learning: graduate release control from teacher to student. This was ensured by the digital platform's educational content and understanding of independent learning algorithms. Standard Operating Procedures (SOPs) were created in order to master these algorithms, visualized in a sequence of actions allowing to work with the subject content independently (with teacher's minimum participation). Simple regulations played a significant role in using the platform as a tool for assessment and data collection:

– only uploaded student's work can be assessed;

– students' work is assessed only on the platform.

In conclusion, the study's main results can be summarized as follows:

1. A science course model adapted for blended learning using a digital platform has been developed and tested twice;

2. Learning ability indicators allowing to analyze the digital platform's data (including the assessment of meta-subject outcomes) have been created;

3. Effective pedagogical tools for personalization have been identified:

- a digital platform with a competency-based approach;

- proficiency scales with educational outcomes written in student language;

- a short-term personalized learning plan in each unit;

- reflective self-evaluation using scales;

- basic learning trajectory - assessment sequence in the unit – for personal learning plan;

- students' progress mapping;

- standard operating procedures (SOPs).

4. This year's experience of a worldwide pandemic schools closure has shown that the digital platform allows school to easier move to online learning: Khoroshkola moved online since March 16, 2020 (before other schools in Russia) almost on a regular schedule for all students due to Sberbank’s platform. The forms of learning in a blended learning environment were familiar to all students and teachers.

Conclusion

1. Moving to digital platform requires major changes in structure and content of physics course;

2. Competency-based digital platform is an effective tool for learning ability;

3. Platform's digital footprint created by students provides data necessary to assess both subject and meta-subject outcomes, primarily the learning ability;

4. Digital platform's possibilities are significantly increased by additional pedagogical tools and strategies, which in the future can be integrated into the platform by artificial intelligence;

5. Obtained effects' quantitative growth has long-term duration and implies gradual development of teaching approach and cooperation in school.

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