STRATEGIES AND FACTORS OF DIGITAL RESOURCES ADOPTION BY RUSSIAN SCHOOL TEACHERS: THE CASE OF YANDEX.TEXTBOOK

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Abstract

The use of digital resources in school education plays an important role in the modern world, especially in the context of distance learning. Despite this, the school remains quite a conservative social institute, where adoption of new technologies faces a number of external and internal barriers. Thus, there may be insufficient material and resource base of the school, lack of additional time and technical support for teachers, as well as personal characteristics of teachers, their internal attitudes and resistance to change, that deter the successful adoption of digital resources in the educational process. The aim of this research is to identify and describe the strategies for the adoption of digital resources in the educational process by Russian school teachers, and also to detect the determinants of differences in their choices of those strategies.

The empirical basis of this study is a randomized controlled trial conducted by researchers of the International Laboratory for Evaluation of Practices and Innovations in Education for the Russian IT company Yandex in the 2018/2019 academic year with 347 Russian schools participated in the study. During the 25 weeks, the experimental group of 165 teachers from these schools was recommended to use the digital service named Yandex.Textbook, which provides individualized digital home tasks in Mathematics and Russian language with automated checking.

We analyzed the average weekly number of home tasks given by every teacher to identify their strategies for using Yandex.Textbook. With the help of time series cluster analysis, there were identified three different strategies for using digital resources. The first one presents a situation where a teacher uses Yandex.Textbook from the very beginning with pauses during school holidays. The second strategy is typical for those teachers who join the experiment later and start with a bigger amount of home tasks than the first ones, to compensate for the lost time. The third strategy is usual for teachers who use Yandex.Textbook only once or twice, despite recommendations.

Further analysis with the use of multinomial regression showed that relationship of teachers' characteristics and their strategy choice. Those teachers who are more likely to choose the 2nd strategy ("delayed start") tend to have a bigger working experience and a lower education level than the teachers that realized the 1st strategy. At the same time, there was no significant relationship between strategy choice and personal ICT and user experience. Besides, chances for choosing the 3rd strategy ("sporadic use"), as well as the 2nd one, are higher for teachers in schools where principals consider the lack of computers with the Internet connection as a significant obstacle to the use of new technologies.

This research shows how the external and internal barriers of Russian school teachers determine the dynamics of digital resource adoption in the educational process. These results allow us to identify teachers who may need additional support for the further integration of digital resources. This is an important result for education policymakers and school principals who plan to introduce new digital learning resources into practice.

Keywords: EdTech, teaching strategies, user experiences, barriers for innovations, digital learning resources.

1 INTRODUCTION

Research into how the adoption of a digital environment in schools is changing the strategies used by teachers to build the educational process has become increasingly relevant in recent years. It is known that the effectiveness of using digital technologies depends on how teachers relate to them and how they are embedded in learning [1], [2]. At the same time, the teacher's attitude and the nature of his attitudes - the rigidity of teachers, closeness to the new in general and to digital technologies in particular - can explain his low and high involvement in digitization processes [3]. Changes in teaching

practices are also associated with the attitudes of teachers [4] and, in turn, may have different relationships with educational results [5], [6].

The process of implementing innovations into the everyday practices of teachers can be considered in the context of several frameworks. At the global level, the model of adoption and use of digital resources was described by E. Rogers in his book "Diffusion of Innovations" [7]. This theory assumes that different members of society implement innovations in different ways, and the degree of their acceptance is described using a standard normal distribution curve. In general, Rogers identifies five segments of society according to the degree of adoption of innovations: a) "Innovators" who seek to be the first to try out a new product, have a sufficient level of IT competence and can apply complex technical knowledge; b) "Early adopters" who form the main backbone of "opinion leaders" and serve as a role model for the rest of society; c) "Early majority", whose representatives may also share an interest in technology and innovation, but the use of these innovations in this group is purely pragmatic; d) The "Late majority" who are skeptical of innovation and start using it only because of economic necessity or growing social pressure; and e) the "Laggards" who do not perceive innovation or refuse to use it at all, both for personal and economic reasons.

This study assesses what strategies teachers use to adopt innovative digital resources into the teaching process, and how these strategies relate to the characteristics of teachers themselves and the schools in which they teach.

2   METHODOLOGY

The empirical basis of the study was the data of the Study of the effectiveness of the use of the digital educational platform for primary schools "Yandex.Textbook", conducted by the International Laboratory for Educational Policy Analysis in 2018-2019. To evaluate the effectiveness of using this digital resource, we used a randomized controlled experiment. The intervention included working with the platform for 25 weeks and implied two experimental groups. In the first experimental group (Group X), teachers were recommended to give students 10 tasks per week. In the second group, teachers received recommendations to give children 20 tasks per week (Group 2X). In addition, the intervention included motivating teachers from experimental groups to work with digital resource: if the recommendations for the proposed number of tasks per week were not fulfilled, the Yandex.Textbook system sent a motivational message to the teacher, and technical support contacted such a teacher to identify the causes of low activity. In other words, the procedure for conducting the experiment made it possible to control for the absence of one of the external barriers to innovation, the lack of technical support.

In total, 343 primary classes from schools in two regions, the Altai Krai and the Novosibirsk Region, took part in the experiment. To participate in the experiment, only those schools were selected whose material and technical base allowed the use of a digital resource: students' access to computers had to be at least 2 to 1, and the incoming Internet speed had to exceed 1 Mb/s. Thus, another potential barrier associated with insufficient resources and technical support for innovation was removed.

The selection of classes for participation in the experiment included preliminary testing of students and questionnaires of teachers and school principals. This allowed us to control another potential barrier to innovation, the lack of tendency to work with ICT.

As a result, 115 classes in the control group, 113 in Group X, and 115 in group 2X took part in the experiment. The distribution into groups was made randomly within the strata by region and by the average result of the iPIPS+ test in mathematics. During the 25 weeks of the study, some teachers from both experimental groups never used the platform. As a result, the identification of strategies for using this digital resource and their analysis were based on data from 165 teachers.

To identify strategies for teachers' adoption of new digital resource, we conducted a cluster analysis of time series, which reflected the dynamics of the weekly number of tasks from the platform in two subjects (mathematics and Russian), given by each teacher during 25 weeks of the experiment (the dimension of the series is 1 week). To identify similar patterns in dynamics that are spaced over time, an algorithm for dynamic transformation of time scales was used (Paparrizos, Gravano, 2017; Müller, 2007; Sakoe, Chiba, 1990), which determines the shortest distances between time series.

Based on the distances allocated for each of the subjects, three clusters were identified, each of that included teachers with similar strategies for using the platform during the experiment. Cluster analysis was carried out separately for each of the subjects.

In the second part of the work, we studied various factors related to the use of new digital recourse by teachers, to identify possible predictors for differences in clusters. For this purpose, a series of multinomial logistic regressions was conducted with the type of strategy for each subject as a dependent variable.

Four groups of characteristics were used as predictors of differences in teachers' choice of different strategies. First, there were the socio-demographic indicators of teachers themselves. Secondly, the indicators of professional experience and qualifications of teachers. Third, the characteristics of schools were used. Finally, the analysis included variables that reflect the ICT experience of teachers and attitudes to innovation of teachers and principals. Exploratory models showed that some characteristics did not show a significant relationship with the teacher's choice of a particular strategy.

The analysis performed has several limitations. First, the use of the multinomial regression method does not allow us to talk about a causal inference. However, in the experiment, the condition of SUTVA was met, as well as temporal logic of the experiment: predictors for inclusion in the analysis reflect the values before the start of use of the platform. Therefore, we can conclude that the strategies described above for teachers to work with digital devices are a consequence, not a cause, of differences between teachers and schools.

3   RESULTS

3.1   Subsection: what strategies do teachers use for adoption of innovative digital resources?

According to the data, on average, teachers gave students 12.45 tasks per week in mathematics and almost the same number, 12.32 tasks, in Russian. However, this amount varied throughout the study.

In general, the teachers did not quite correctly withstand the experimental conditions. Usually, teachers gave children up to 50 math tasks and 50 Russian language tasks per week. However, it is possible to distinguish a group of the most active teachers who assigned their students more than 200 tasks per week. It is important to note that this volume is not a workload for several weeks ahead: in the future, these students also received weekly tasks. Analysis of the dynamics of the weekly number of tasks on mathematics and the Russian language, which teachers gave to children to solve, allowed us to identify several clusters that characterize the key strategies for using the platform.

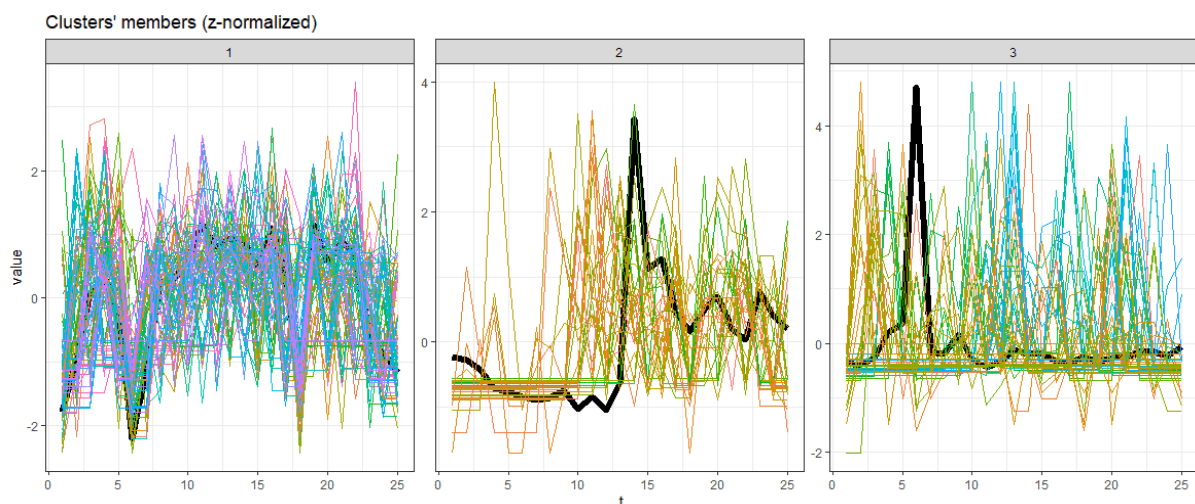Thus, three clusters were allocated for mathematics (Fig. 1.1).

Figure 1.1. Strategies for teachers' use of the platform in mathematics.

The first cluster is characterized by a smooth increase in the number of math tasks during the first 3 weeks of the experiment and a gradual decline in their number in the last 3 weeks. Another characteristic of this cluster is two declines in teacher activity, which presumably correspond to vacation periods. Using the method of dynamic transformation of time scales allowed us to take into account different dates of the beginning and duration of holidays in schools with different learning

systems (quarter, module, semester). In other words, teachers who are in the first cluster adhere to the strategy of smooth "entry" into work with the new digital tool and smooth "exit" from it and reduce active use during the holidays. This strategy is followed by 83 teachers out of 165 (50.3%).

The second cluster is characterized by a delayed start of teacher activity on the platform. During the first weeks of the experiment, most of the teachers from this cluster did not actively use the platform, and the number of tasks increased only in week 10-12. At the same time, the volume of tasks at first exceeded the average values for similar indicators in the first cluster, however, then there was a gradual decrease and levelling of activity. Thus, the teachers of the second cluster demonstrate a different strategy for working with the digital resource: a large amount of homework at a late start may indicate some entry barriers to the use of digital tools, which were later overcome, and a further attempt to compensate for the "missed" weeks. This strategy is followed by 28 teachers (16.9%).

A distinctive feature of the third cluster is a single surge in teacher activity on the platform. On the one hand, these may be teachers who, in the middle of the experiment, gave students a voluminous homework assignment for a long time ahead (for example, for the entire quarter), and then did not use the platform on a regular basis. Also, teachers who used the platform on a one-time basis but later refused to work with it, could get into this cluster. In any case, such dynamics of the share of tasks also indicates potential external barriers and internal obstacles that prevent the active use of digital tools in the educational process. This strategy of one-time inclusion of digital tools in the educational process is typical for 54 teachers (32.7%).

The clusters formed in the analysis of the dynamics of the number of tasks in the Russian language, in general, coincide with the identified trends for mathematics (Figure 1.2). However, there are some differences.
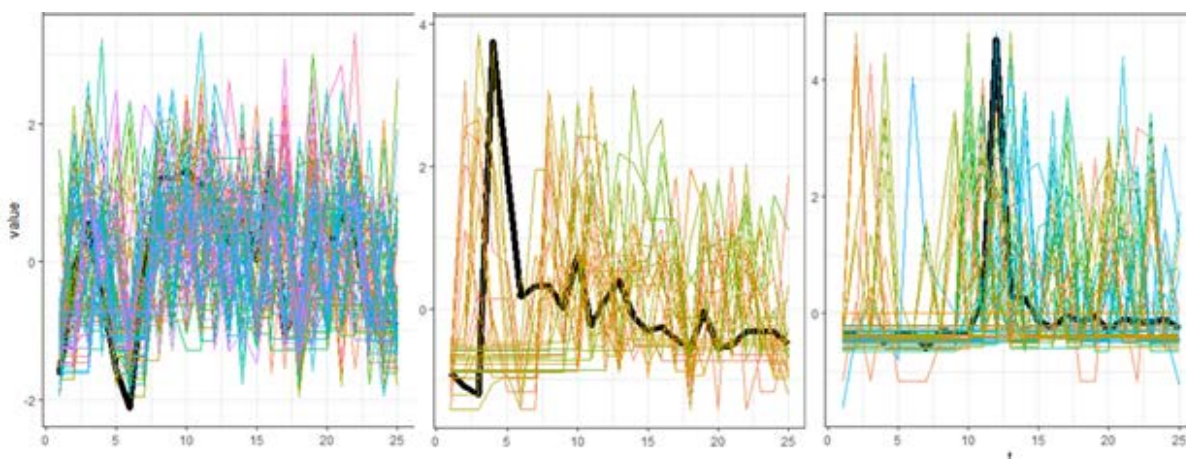

Figure 1.2. Strategies for teachers' use of the platform in the Russian language.

The first cluster, as in the case of mathematics, is characterized by a smooth immersion of teachers in working with digital resource and a smooth exit at the end of the experiment, as well as two periods of activity decline during the holidays. However, unlike math, there is a slight decrease in teacher activity on the platform between holidays. In total, 88 teachers (53.3%) adhere to this strategy for working with tasks in the Russian language.

In the second cluster, as for mathematics, there is a delayed start of teacher activity on the platform. In contrast to mathematics, the start occurs earlier, at 7-10 week of the experiment. In addition, in the last 7 weeks, the number of tasks that teachers gave has significantly reduced, more than it was in the case of mathematics. In total, 25 teachers (15.2%) demonstrate this late start strategy.

In the third cluster, the trends in the dynamics of the number of tasks are the same as in a similar cluster for mathematics: there is a one-time surge in the activity of teachers on the platform. But while in the case of mathematics, such a "test" of the platform in most cases occurred at the beginning of the experiment, in the case of the Russian language, teachers of the third cluster turned to the platform in the middle and near the end of the experiment. This strategy is typical for 52 teachers (31.5%).

In general, clusters for mathematics and Russian are significantly correlated with each other (correlation coefficient 0.68 at p-value<0.01). In other words, teachers follow the same strategy for working with digital tools for different subjects.

3.2 Subsection: how is the choice of strategy related to the characteristics of teachers and schools?

The results of the multinomial regression analysis with the types of strategy as a dependent variable are presented in Tab. 1. The first type of strategy was chosen as a reference type for each of the subjects. In that strategy teachers gradually increased the use of the digital resource and gradually reduced it by the end of the experiment, pausing activity for periods of vacation.

Table 1. Results of estimation of the multinomial logistic regression
for the probability of getting into the second or third cluster.

	Cluster in math:		Cluster in Russian:	
	2	3	2	3
Teacher's age	0.011	0.079	0.062	0.040
	(0.070)	(0.050)	(0.070)	(0.049)
Years of work	-0.041	-0.083*	-0.095	0.011
	(0.061)	(0.043)	(0.059)	(0.042)
Higher education	-2.152***	-0.237	0.856	-0.330
	(0.580)	(0.501)	(0.761)	(0.440)
Resistance to change (standardized)	0.482*	0.167	0.235	0.202
	(0.260)	(0.200)	(0.275)	(0.199)
Teacher's use of a computer (standardized)	0.098	0.138	0.333	0.180
	(0.276)	(0.191)	(0.288)	(0.199)
Type of school: gymnasium or liceum	1.802**	-0.118	-1.139	0.734
	(0.809)	(0.643)	(1.180)	(0.585)
Lack of computers with access to Internet	0.696**	-0.024	0.762**	0.398*
	(0.304)	(0.197)	(0.305)	(0.205)
Books at home	0.225	-0.019	0.880***	-0.402
	(0.311)	(0.230)	(0.330)	(0.248)
Constant	-2.050	-2.006	-7.244***	-2.104
	(2.255)	(1.708)	(2.725)	(1.700)
Akaike Inf. Crit.	306.035	306.035	295.667	295.667
Standard errors in parentheses	* p<0.01, ** p<0.05, * p<0.1			

The analysis shows that increasing the length of teaching experience for a year reduces the probability of choosing a third strategy in mathematics by 8% compared to the first strategy, all other things being equal (p<0.1). In other words, the longer a teacher works at school, the more likely they will use the platform to work with math for a few times only, instead of regular usage.

Higher education compared to vocational education reduces the probability of getting into the second cluster in mathematics instead of the first by 88% (p<0.01). That is, teachers with higher education were more likely to give tasks in mathematics during all the experiment, and teachers with vocational education were more likely to start later.

Increasing the resistance to change by one standard deviation increases the probability of getting into the second cluster in mathematics by 62% (p<0.1). Teachers who showed a negative attitude or unwillingness to change when answering the questionnaire were less likely to start using the math platform at the beginning of the experiment and more likely to join later.

The intensity of the teacher's use of a computer, smartphone or tablet for personal purposes is not statistically significantly associated with getting into a particular cluster (in addition to using a computer, Internet use was also checked, and it was also not significant). Thus, personal experience of using technical tools and the Internet was not associated with a preference for any strategy.

Working in a gymnasium or lyceum instead of a general school increased the probability of getting into the second cluster in mathematics by 6 times ($p < 0.05$).

The lack of computers with Internet access, given that, in the principal's opinion, makes it difficult the implementation of ICT in school, increases the probability to get to the second cluster in both mathematics and Russian language by 2 times, and in the third cluster in the Russian language by 1.5 times ($p < 0.05$). So, at schools where the principal assesses the lack of Internet in the school as a significant obstacle to using ICT, teachers were more likely to start late on the platform in both subjects and to refuse to use the platform in Russian.

The number of books at the teacher's home increases the probability of getting into the second cluster in the Russian language by 2.4 times ($p < 0.01$).

The graphs below show the marginal effect of how the school principal assesses the negative impact of poor Internet access on the implementation of ICT, on the probability of getting into a particular cluster, depending on the teacher's education (Fig. 2.1, 2.2).
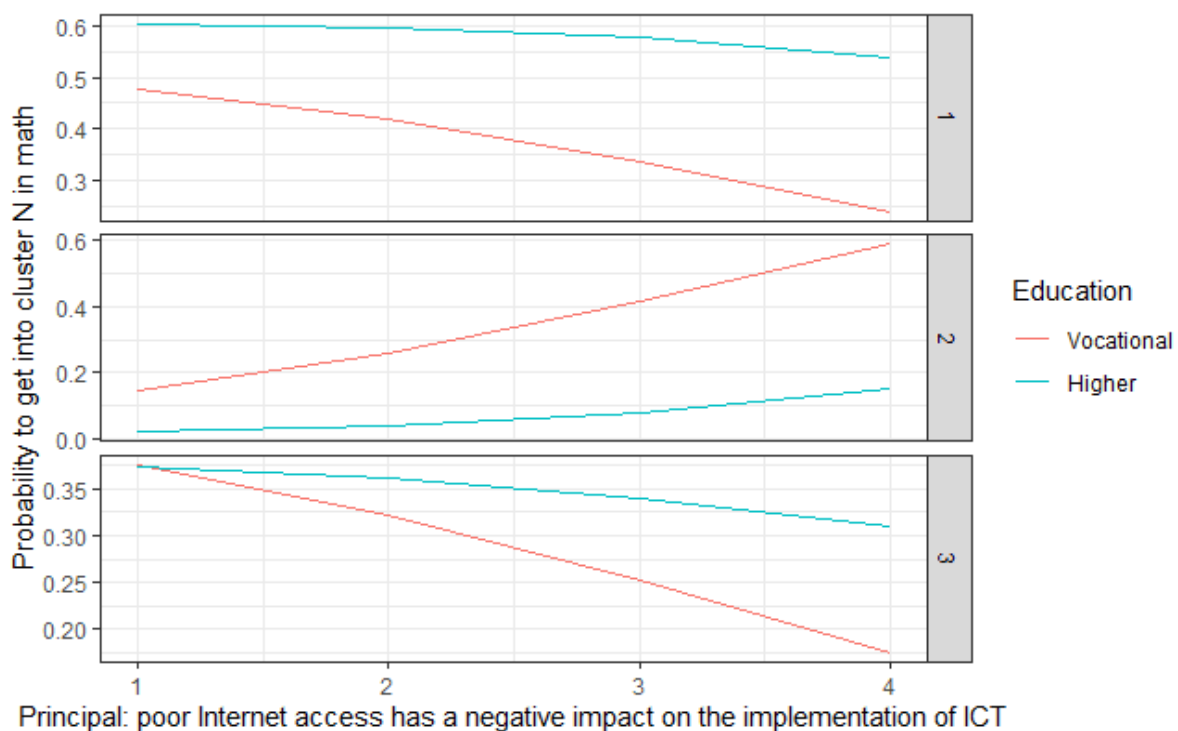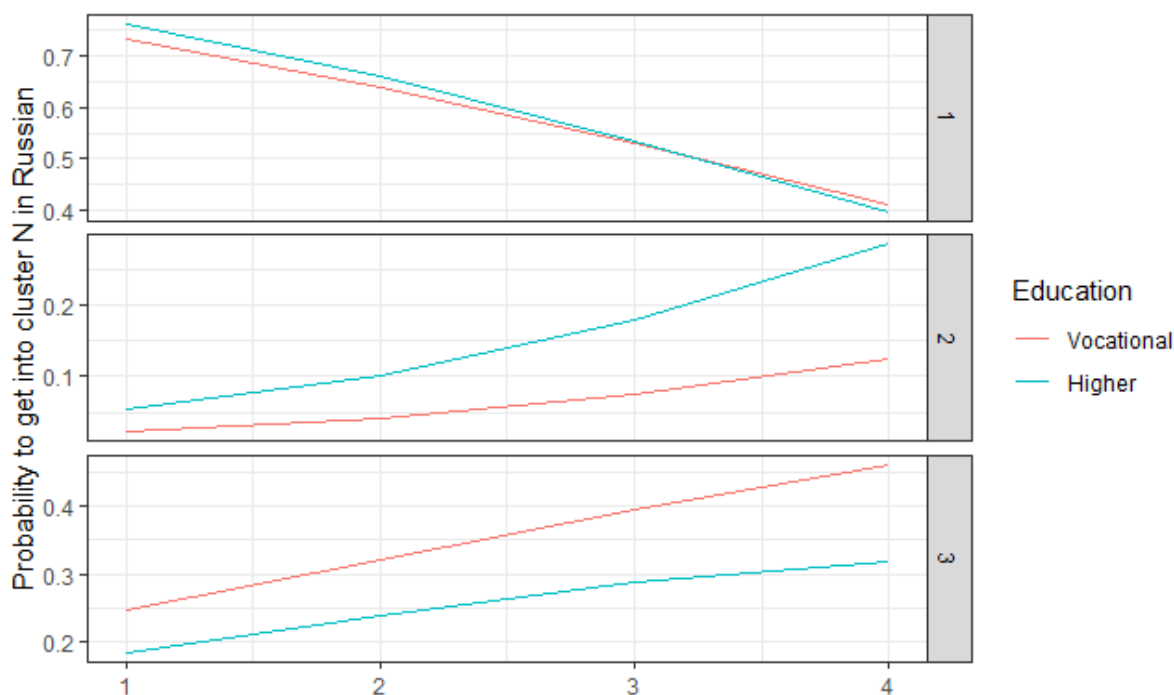

Figure 2.1. Marginal effect of lack of Internet access on the probability of getting into each cluster in mathematics, divided by teacher's education level.

If the principal considered poor Internet access to be a significant obstacle to the implementation of ICT, then in such schools, teachers with vocational education were more likely to start using the platform in math later, but teachers with higher education were almost not affected by this position of the headmaster.

As for the Russian language, teachers with any level of education were less likely to use the platform regularly and more often started late or did not use it at all. At the same time, teachers with higher education more often chose the second strategy, while teachers with vocational education chose the third.

Figure 2.2. Marginal effect of lack of Internet access on the probability of getting into each cluster in the Russian language, divided by teacher's education level.

4 CONCLUSIONS

The analysis made it possible to identify three key strategies for teachers to work with the Yandex.Textbook digital resource, and those strategies mostly stayed the same regardless of the subject (mathematics or Russian) or the volume of recommended tasks. The first strategy involved regular use of the platform with a break for the holidays. This strategy was followed by most respondents. The second strategy is characterized by a late start of working with a digital resource and an attempt to compensate for lost time with many homework assignments. How effective such compensation can be in terms of educational outcomes remains to be seen. The third strategy is a single use of Yandex.Textbook with a further refusal to work with this digital resource.

The analysis showed that even under formally favorable conditions for innovation, not all teachers adopted the use of new digital resources into their permanent pedagogical arsenal. Selection of schools whose resource base and teacher competencies met the technical requirements of the Yandex.Textbook service for participation in the experiment, as well as those who themselves wanted to participate in the study, allowed to mostly overcome key potential barriers to innovation. However, even in such circumstances, not all teachers were equally active working with the proposed service.

We may assume that teachers who were later and less actively involved in working with the digital resource are, in Rogers' terms, groups of "late majority" and "laggards". In our analysis, these groups are represented by a significant number of teachers: they were slightly less than a half of the total number of respondents. This shows that even in favorable conditions for the adoption of innovation and with the support of the administration, it is necessary to pay special attention to digital adaptation and methodological support of teachers.

Teachers who implemented the second strategy of working with the platform often had less work experience and a lower level of education than their colleagues who were involved in working with the resource since the very beginning of the experiment. Since the level of professional competence of a teacher is itself related to the academic results of students, this further limits the educational opportunities of students. In addition, such teachers are more resistant to change and take longer to master a new product or practice. There is a situation of double inequality when the inequality of skills is superimposed on the digital inequality.

Of particular interest are teachers who implement the third strategy of working with digital resources, which is a single use of such a tool, despite regular reminders from the technical support of the service. Analysis of the characteristics of teachers who chose this strategy did not show significant differences in the observed indicators. In other words, we are not talking about external barriers, but about internal attitudes of the teacher that are not related to the use of ICT.

It is also worth noting that a significant predictor for choosing the second and third strategies was the position of the headmaster regarding the number of computers with Internet access, even though the participating schools were initially selected according to this criterion. The negative perception of the principal about the digital capabilities of the school turned out to be a more significant factor for teachers with vocational education. Perhaps, in the case of school administration, the latent factor for innovation is personal biases and attitudes about innovation, as in the case of a group of "lagging" teachers. Therefore, further research is needed on the factors of low engagement in the use of digital resources.

ACKNOWLEDGEMENTS

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