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CHAPTER V

Comparison of Studies Based on Adaptive Learning Environments in Physics-Chemistry-Biology and Science Education with Other Fields: An Example of Systematic Review

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Introduction

Adaptive learning systems are an innovative approach that aims to optimise individual learning processes using the possibilities offered by modern educational technologies. These systems offer personalised learning experiences in line with learners' preferences, knowledge levels, interests and goals. Adaptive learning ensures that each individual is supported with content and strategies appropriate to their different learning styles, speeds and needs (Brusilovsky, 1996).

Hypermedia is a digital learning environment that includes static materials such as pictures, tables, graphics as well as dynamic

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materials such as animations, diagrams, videos and audios. These environments offer enriched learning experiences through various multimedia elements and enable learners to access interactive and versatile information (Ceran, 2021; Tolhurst, 1995; cited in Karadeniz, 2006).

Adaptive learning systems personalise and optimise learning processes using hypermedia technologies. These systems provide access to the most appropriate pieces of information by organising content and links according to the individual characteristics of learners. Thus, the learning process is managed in a more targeted and effective way (Brusilovsky, 1996).

Skinner's learning mechanisms have an approach that prioritises the learning object rather than learners' interests and needs. These mechanisms aim to learn information through immediate feedback and reinforcement, regardless of the learner's motivation and learning characteristics (Wegner et al., 1987). Skinner's behaviourist learning theory focuses on the reinforcement of responses to certain stimuli. This approach predicts that learning takes place through automatic and mechanical processes.

Carroll (1963) argued that a more effective learning environment can be created by providing learners with certain opportunities and appropriate time. Carroll's model provides adaptability by allowing the learner to organise the learning objects. This approach allows the learning process to be shaped according to individual speed and needs. In Carroll's model, it is accepted that each individual's learning capacity and duration may be different and learning materials and processes are adjusted accordingly.

Keller (1968) advocates an individualised learning approach. Keller's model prioritises individual differences based on the learner's needs and learning speed. This model optimises the learning process by taking into account the unique learning speed and style of each individual. Keller emphasises that learning processes should be designed by taking into account individual differences and aims to increase the motivation and success of learners with this approach.

Bloom (1971) developed the complete learning model by combining the approaches of Skinner, Carroll and Keller. Bloom's complete learning model envisages instructional design according to learner characteristics. This model provides adaptations with appropriate materials after determining the learner's prior knowledge and academic self-perception. Bloom's model shows that learning objects and attributes are adaptive. Bloom argues that every learner can achieve success in the complete learning model and in this direction, he suggests that teaching methods and materials should be organised according to individual needs.

The development of computer technology and artificial intelligence applications has increased the effectiveness of adaptive learning systems (Gültekin & Burak, 2019; Güngören, 2015). Technology allows the learner's individual characteristics to be determined more precisely and more effective adaptations to be made. Therefore, adaptive learning systems cannot be considered independent of technology.

Kerr (2016) defines adaptive learning as "educational technology that provides an automated, dynamic and interactive teaching process". Today, adaptive learning systems have become more advanced and effective with the developing technology. Artificial intelligence and machine learning algorithms offer personalised learning experiences by analysing the needs and preferences of individual learners more accurately. These technologies increase the success and satisfaction of learners by making learning processes more flexible and dynamic (Wang & Hannafin, 2005).

The approaches that form the basis of adaptive learning can be listed as "Macro", "Ability-Method", "Micro", "Ability, Task Performance and Response Sensitive" and "Constructivist-Collaborative". Macro adaptive learning is the grouping of students according to the achievement level determined by teachers in the classroom environment and managing the learning process with activities appropriate to this grouping.

This approach involves more large-scale and general adaptations. Macro-adaptation is used to identify general teaching strategies and objectives and makes adaptations to the needs of large groups of students. In this approach, learners are grouped and supported with specific strategies to achieve general learning goals. Teachers form groups according to the achievement levels of students in the classroom environment and provide activities and materials suitable for each group. Micro-adaptive learning involves smaller scale and detailed adaptations according to the needs of individual learners. This approach aims to optimise the individual learning journey of each learner. Micro-adaptations enable learning materials to be tailored and personalised to individual learner needs. In this approach, each student's learning process is individually assessed and tailored to their needs. Learners are supported with materials appropriate to their pace and style and receive personalised feedback.

E-learning systems enable learners to receive education independent of time and space. In these systems, the learning process is largely dependent on the efficiency and effectiveness of individual learners. E-learning provides access to learning materials from anywhere thanks to the possibilities offered by technology. These systems allow learners to use learning materials according to their own pace and time.

Applying different learning strategies in accordance with different learner characteristics and realising the learning process in various ways are effective in increasing learner success and satisfaction (Tuna & Öztürk, 2015). E-learning provides access to learning materials from anywhere thanks to the possibilities offered by technology. These systems allow learners to use learning materials according to their own pace and time.

Adaptive learning is an educational approach that personalises the learning experience in accordance with students' individual needs and learning styles. This approach recognises that each student has a different learning pace, preferred learning methods and strengths/weaknesses. Adaptive learning adapts to

these differences by providing students with specific feedback, personalising learning materials and content, and monitoring students' progress. Adaptive learning aims to ensure that each student learns in the best way possible, taking into account individual differences. This approach makes the learning process more flexible and dynamic.

Adaptive learning systems are an approach that personalises and optimises learning processes by focusing on individual learning needs and preferences. These systems combine technology and education to increase the success and satisfaction of learners. Adaptive learning, which developed with the combination of the approaches of educators such as Skinner, Carroll and Keller in the historical perspective, has become more effective today with the opportunities provided by artificial intelligence and computer technologies.

In the future, these systems are expected to be used more widely and effectively in education. Adaptive learning systems will continue to open new horizons in education by offering flexible and dynamic learning experiences suitable for individual differences. These systems provide the necessary tools and resources to ensure that each individual learns in the best way possible. The importance of adaptive learning systems is increasing day by day to improve the quality of education and maximise the potential of learners. Therefore, the development and dissemination of adaptive learning systems will be the key to success and innovation in education.

In this study, it is aimed to conduct a systematic literature review of postgraduate theses and articles indexed in some databases (Scopus (ELSEVIER), ERIC, Google Schoolar) on adaptive learning in educational fields between 2014-2024 in Türkiye.

Method

The model of this research is a qualitative systematic literature review. In the research, academic studies on adaptive learning method between 2014-2024 were analysed. In order to examine the studies systematically, the review form developed by Gültekin and Burak (2019) was used (Güyer & Çebi, 2015; Özyurt & Özyurt, 2015). Articles indexed in Scopus (ELSEVIER), ERIC,

Google Schoolar databases and theses in YÖK Thesis Centre were scanned. The keywords "adaptive learning, adaptive learning" were used during the search. Firstly, the studies conducted outside the field of education were eliminated and the remaining 35 studies were reduced. In the selection phase, the studies conducted by review and meta-analysis method were eliminated and only experimental studies remained. As a result, a total of 28 studies, 11 thesis studies and 17 articles, were analysed. Information about the theses and articles used in the study is given in Appendix 1.

Of the eleven (11) theses used in this study, six (5) are master's theses and eight (7) are doctoral theses. Seventeen of the articles used in the study were research articles. All studies were coded and listed. Theses were coded as "T" and articles were coded as "A".

The examination form used in the study consists of 3 main basic questions. These are;

1. For what purposes were the theses and articles carried out within the scope of adaptive learning method?
2. What are the methodological applications in theses and articles conducted within the scope of adaptive learning method?
3. How did the process of adaptive learning environment design progress in the theses and articles conducted within the scope of adaptive learning method?

Findings

In the systematic literature review, the articles and theses examined in the study were examined in a way to include the general purpose of the research, research design, model, sample size, sample group, study area, data collection tools, learning environment design processes and results, and the findings were tabulated.

The findings related to the general aims of the studies are shown in Table 1.

Table 1: General Purpose of the Research

General Purpose of the Research	Thesis	Article
	f	f
The effect of adaptability levels and participants' academic achievement, satisfaction, cognitive load	8	3
Designing, implementing and evaluating adaptive learning environment	5	3
The effect of student navigation strategies on navigation time, number of visited links, perception of getting lost in an adaptive learning environment	1	
Focus on the gap in understanding the factors influencing the scaled implementation of adaptive learning		1
To examine whether preschool teachers' adaptive mathematics learning support at micro and macro level can be developed separately		1
Determination of gamification design principles based on adaptability	1	
Opinions of Students Using Adaptive Online Learning Environment		2
Implementation of adaptive learning in higher education institutions through Moodle LMS		1

When Table 1 is analysed; 11 studies are related to the effect of adaptability levels on participants' academic achievement, satisfaction and cognitive load. 8 studies are related to designing, implementing and evaluating adaptive learning environments. The aim of 2 studies is the opinions of students using adaptive online learning environment. Other studies include objectives such as student navigation strategies in adaptive learning environment, navigation time, number of links visited, effect of perception of getting lost, focusing on the gap in understanding the factors affecting the scaled implementation of adaptive learning. It also aims to examine whether adaptive mathematics learning support for preschool teachers at micro and macro levels can be developed separately, to determine the principles of adaptive gamification design, and to implement adaptive learning in higher education institutions through Moodle LMS.

Table 2: Methodological Findings

Sub Dimensions	Features	Thesis	Article
		f	f
Research Design/Model	Mix	4	2
	Experimental	4	10
	Development design	-	1
	Factorial design	2	-
	Qualitative	2	4
Sample Size	1-10	-	1
	11-100	7	10
	101-200	2	4
Sample group	Student	9	9
	Teacher	-	3
	Field Specialist	4	3
School level	Pre-school		1
	Primary education	3	1
	Secondary education		2
	Higher Education	8	10
Data Collection Tools	Scale	5	6
	Academic achievement test	3	4
	Questionnaire	3	2
	Observation	1	-
	Interview	5	5
	Adaptive Learning Environment Usage Records	3	2
	Alternative Measurement Tools	1	1
	Rubric	1	-
	Inventory	1	-
	Delphi method	1	1
Data Analysis Techniques	t-test	4	2
	ANOVA	2	2
	Wilcoxon Signed ranks	1	2
	Mann Whitney U	2	1
	Kruskal Wallis	2	-
	ANCOVA	3	1
	Content analysis	2	2
	Descriptive analysis	2	3
	Thematic analysis	1	

When the theses and articles on adaptive learning are

examined in Table 2, mixed research method was used in 6 studies in the research design and model category. In 14 studies, experimental designs are seen. In 6 studies, qualitative research method was applied. In 2 theses, researchers used factorial design. When the studies are analyzed according to the sample size, the sample size of 1 study is 1-10 people, the sample size of 17 studies is 11-100, and the sample size of 6 studies is between 101-200.

When the sample groups are analyzed, it is seen that 18 studies were conducted with students, 7 studies were conducted with field experts and 3 studies were conducted with teachers. When analyzed in terms of the education levels at which the studies were conducted; 18 studies were conducted at higher education level, 4 studies were conducted at primary education level, two studies were conducted at secondary education level and one study was conducted at pre-school level.

When the data collection tools of the studies are examined; scales were used in 11 studies, interview forms in 10 studies, academic achievement tests in 7 studies, questionnaires in 5 studies, alternative measurement methods in 2 studies, adaptive learning environment records in 5 studies, Delphi technique in 2 studies, observation, rubric and inventory in one study. When the data analysis techniques of the studies were examined; t-test analysis was used in 6 studies, ANOVA analysis in 4 studies, Mann Whitney-U test in 3 studies, Wilcoxon signed-rank analysis in 3 studies, Kruskal Wallis analysis in 2 studies, and ANCOVA analysis in 4 studies. In qualitative studies, content analysis was conducted in 4 studies, descriptive analysis in 5 studies and thematic analysis in one study.

In Table 3, the sub-dimensions of adaptive learning environment design in the studies on adaptive learning are analyzed. According to the individual characteristics taken as basis in learner modeling, the studies were conducted as follows; 7 studies addressed prior knowledge level, 7 studies addressed learning styles, 4 studies addressed the use of adaptive learning environment, 3 studies

addressed cognitive styles, 1 study addressed learning approach. When the adaptation was examined according to the type of modeling; 9 studies used content modeling, 2 studies used strolling modeling. 6 studies used both content and strolling modeling.

Table 3: Design Processes for Adaptive Learning Environments

Design Process Sub Dimensions	Techniques and Tools	Thesis	Article
		f	f
Individual Characteristics Based on Learner Modeling	Prior knowledge level	5	2
	Learning styles	5	2
	Cognitive styles	1	2
	Use of adaptive learning environment	3	1
	Approach to learning	1	
Adaptation Modeling Type	Content	2	7
	Strolling	2	-
	Content and strolling	5	1
Updating Approach of Adaptive Learning Environment	Statics	1	2
	Dynamic	5	4
	Static and Dynamics	2	-
Adaptive Learning Environment	Classroom Environment	5	4
	Distance Learning	3	2
	Hybrid	1	2

When analyzed according to the updating approach of the adaptive learning environment; it is seen that 3 studies used static updating and 9 studies used dynamic modeling. 2 studies used both static and dynamic modeling. When the studies are analyzed according to adaptive learning environments, it is seen that 9 studies were conducted in classroom environment, 5 studies were conducted remotely and 3 studies were hybrid.

In the systematic literature review in Table 4, when all the studies that constitute the study group of this research are taken into consideration, it is seen that all theses related to adaptive learning environments are in the fields of computer instructional technologies, social sciences, English and Turkish language

teaching, and pre-school teaching other than the fields of physics education, chemistry education, biology education and science education.

Table 4: Distribution of related studies according to fields

Field	Thesis	Article
	f	f
Physics Education	-	-
Chemistry Education	-	3
Biology Education	-	2
Science Education	-	1
Others	11	12

When the articles were analyzed, it was found that most of the articles were in the fields of chemistry and biology among the PSE (physics-chemistry-biology) courses. There was one article each in the fields of Physics education and Science education. This situation shows that the inclusion of adaptive learning in teaching in the fields of science is still not widespread. It was seen that most articles and theses were in the field of computer and instructional technology education.

Discussion and Conclusion

In this study, a systematic literature review of the studies on teaching based on adaptive learning environments in postgraduate theses in Turkey between 2014 and 2024 and in journals indexed in the previously mentioned indexes was conducted. For this purpose, the studies constituting the study group of the research were examined by considering their aims, methodologies used, types of dimensions in the adaptive learning environment design process, and their distribution according to physics-chemistry-biology-science and other branches.

According to the findings of the study, it is seen that the purposes of the theses and articles examined in the research are

mostly to examine the effects of adaptive learning environments such as achievement and satisfaction of the sample. In addition, it is seen that the researchers designed and implemented a new adaptive learning environment and evaluated the effects of these environments on education. When the postgraduate theses on adaptive learning environments are examined, it is seen that adaptive learning is significantly different in favor of adaptive learning in terms of academic achievement, productivity and navigation strategies in the majority of theses (Baz, 2016; Burak, 2020; Cesur, 2023; Güngören, 2015). There are also a small number of theses in which adaptive learning does not cause a significant difference in terms of academic achievement, productivity and navigation strategies (Çebi, 2014; Özkeskin, 2018).

When the methodological findings of the study are examined, we can see that the studies were mostly conducted with mixed and experimental research designs (Aslan et al., 2018; Aydoğdu et al., 2019; Burak, 2020; Çetinkaya & Keser, 2018; Erdoğdu, 2020; Mirata et al., 2020; Özkeskin, 2018; Wullschleger et al., 2023). It is seen that the studies are mostly on students and students in higher education institutions (Aydoğdu et al., 2019; Erdoğdu, 2020; Mirata et al., 2020; Baz & Tetik, 2017). The reason for this can be considered that there should be a technical infrastructure for the creation of adaptive learning environments. It is seen that quantitative data analysis is mostly used in the data in the studies.

When the findings of the adaptive learning design process are examined, prior knowledge level and learning styles are emphasized in the individual characteristics based on learner modeling (Aslan et al., 2018; Erdoğdu, 2020). When adaptive modeling types are examined, content / content navigation types were mostly used (Doğan & Çakır, 2019). When the approaches to updating the adaptive learning environment are examined, it is seen that dynamic/static and dynamic approaches are in the majority (Baz, 2016; Burak, 2020; Cesur, 2023; Çetinkaya & Keser, 2018).

In the postgraduate theses on adaptive learning environments, it was determined that there were no postgraduate theses in the fields of physics-chemistry-biology and science in the selected date range. When the articles were analyzed, it was found that most of the articles were in the fields of chemistry and biology among the PSB (Physics-chemistry-biology) courses. In the field of chemistry, three articles were found to be related to adaptive learning (Agbonifo et al., 2020; Fautch, 2019; Gabriel & Osuafor, 2021). There are two articles in the field of biology education (Aleksandrovich, 2024; Aguar et al. 2017). There is one article in the field of science education (Aguar et al. 2017). This shows that the incorporation of adaptive learning into teaching in science fields is still not widespread. It was seen that most articles and theses were in the field of computer and instructional technology education (Aydın, 2021; Cesur, 2023; Emek, 2019).

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Appendix 1: Information about the theses and articles used in the study

Year	Name of the study	Author	Type
2014	Uyarlanabilir öğrenme ortamlarında gezinme stratejisinin gezinme süresi ve yolu ile kaybolma algısına etkisi	Çelebi, 2014	master's thesis
2015	Uyarlanabilir eğitsel web ortamlarının öğrencilerin akademik başarılarına ve motivasyonuna etkisi	Güngören, 2015	doctoral thesis
2016	Web tabanlı bir uyarlanabilir çevrimiçi öğrenme ortamının harmanlanmış öğretim modeline uygun olarak tasarlanması ve öğrenci başarısına etkisi	Baz, 2016	doctoral thesis
2018	Çevrimiçi dersler için uyarlanabilirliğe dayalı oyunlaştırma tasarımı ilkelerinin incelenmesi	Sezgin, 2018	doctoral thesis
2018	Yarılanabilir açık ve uzaktan öğrenme sisteminin tasarımı, geliştirilmesi ve değerlendirilmesi	Özkeskin, 2018	doctoral thesis
2019	SQL öğrenimi için oyunlaştırma destekli uyarlanabilir öğrenme ortamı: geliştirme, uygulama, değerlendirme	Emek, 2019	master's thesis

2020	İlkokul sosyal bilgiler öğretimine yönelik uyarlanabilir bir öğrenme ortamının tasarlanması, uygulanması ve değerlendirilmesi	Burak, 2020	doctoral thesis
2021	Ortaokul öğrencilerinin kodlama öğretimine yönelik uyarlanabilir eğitsel oyun ortamının tasarlanması ve değerlendirilmesi	Aydın, 2021	doctoral thesis
2021	Bilgi güvenliği eğitimine yönelik uyarlanabilir öğrenme ortamının geliştirilmesi	Ceran, 2021	doctoral thesis
2023	Uyarlanabilir öğretimin kaybolma ve bilişsel yüklenmeye etkisinin öğrencilerin bilişsel stilleri açısından incelenmesi	Cesur, 2023	master's thesis
2023	Bilişim etiği öğretiminde oyunlaştırma tabanlı uyarlanabilir bir öğrenme ortamının öğretmen eğitiminde etkililiğinin incelenmesi	Konuk, 2023	master's thesis
2017	Uyarlanabilir çevrimiçi öğrenme ortamı kullanan öğrencilerin ortam kullanımına ilişkin görüşleri	Baz & Tetik	article
2017	Considerations on interdisciplinary instruction and design influenced by adaptive learning. A case study involving biology, computer science, mathematics, and statistics.	Aguar, vd. 2017	article
2018	Uyarlanabilir uzaktan hizmetiçi eğitimin başarı ve eğitimin tamamlama süresine etkisi ile öğretmen görüşleri	Aslan, Göksu & Karaman, 2018	article
2018	Uyarlanabilir eğitsel içerikli web ortamlarının tasarım ilkeleri: öğrenen modeli	Çetinkaya & Keser, 2018.	article
2019	İngilizce öğretiminde kişiselleştirmenin üniversite öğrencilerinin başarılarına etkisi ve uygulamaya dair öğrenci görüşleri	Doğan &Çakır, 2019	article
2019	Adaptive Learning Technology in General Chemistry: Does It Support Student Success?.	Fautch, J. M.	article
2019	Uyarlanabilir öğrenme ortamlarında felder ve sılverman öğrenme stillerine göre geliştirilmiş içeriklerin öğrenci başarısı üzerindeki etkisinin incelenmesi	Aydoğdu, Aydoğdu & Ocak, 2019	article

2020	Constructing a design framework and pedagogical approach for adaptive in Higher Education: A Practitioner's Perspective	Cavanagh, vd. 2020	article
2020	Challenges and contexts in establishing adaptive learning in higher education: findings from a Delphi study.	Mirata vd., 2020	article
2020	Uyarlanabilir motivasyon stratejileri kullanmanın öğrenci motivasyonu ve başarısına etkisi	Erdoğdu, 2020	article
2020	Implementation of adaptive learning at higher education institutions by means of moodle lms	Morze, vd., 2020	article
2020	When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction.	Wang, vd., 2020	article
2020	A chemistry laboratory platform enhanced with virtual reality for students' adaptive learning.	Agbonifo, vd., 2020	article
2021	Effect of Adaptive Learning Approach on Students' Achievement in Chemistry in Awka Education Zone of Anambra State.	Gabriel & Osuafor, 2021	article
2023	Improving the quality of adaptive learning support provided by kindergarten teachers in play-based mathematical learning situations.	Wullschleger, vd., 2023	article
2023	Role of organisational readiness and stakeholder acceptance: an implementation framework of adaptive learning for higher education	Mirata &Bergamin, 2023	article
2024	Transformative applications in biology education: A case study on the efficacy of adaptive learning with numerical insights.	Aleksandrovic vd., 2024	article

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Bidge Yayınları", Üniversitelerarası Kurul Başkanlığı (ÜAK)'nın Doçentlik Başvuru Şartlarında belirtilmiş tanıma göre "Tanınmış Uluslararası Yayınevi" statüsündedir. ÜAK söz konusu tanımı; "Uluslararası Yayınevi: En az beş yıl uluslararası düzeyde düzenli faaliyet yürüten, yayımladığı kitaplar Yükseköğretim Kurulunca tanınan sıralama kuruluşlarınca belirlenen dünyada ilk 500'e giren üniversite kütüphanelerinde kataloglanan ve aynı alanda farklı yazarlara ait en az 20 kitap yayınlamış yayınevidir" şeklinde ifade etmiştir.

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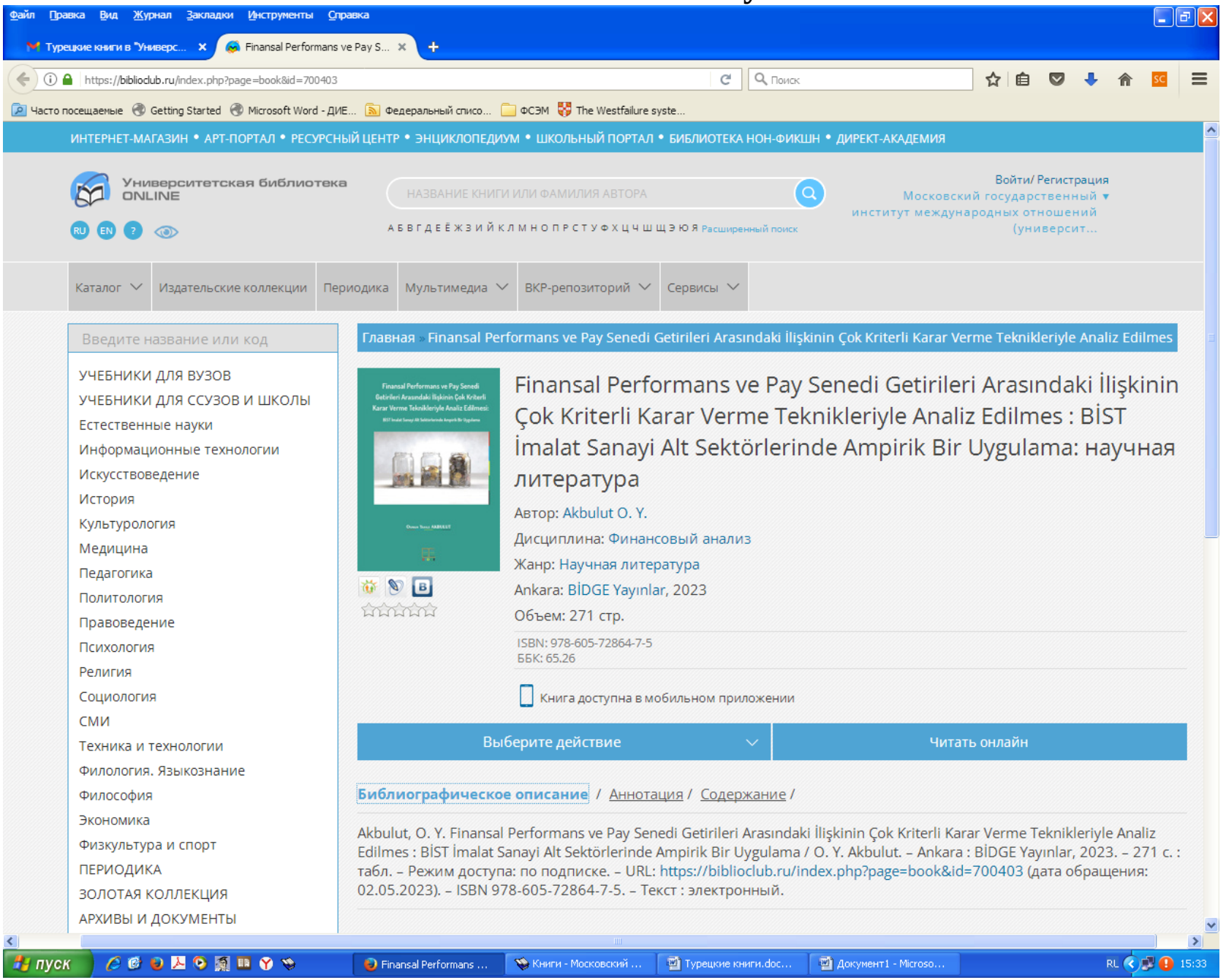

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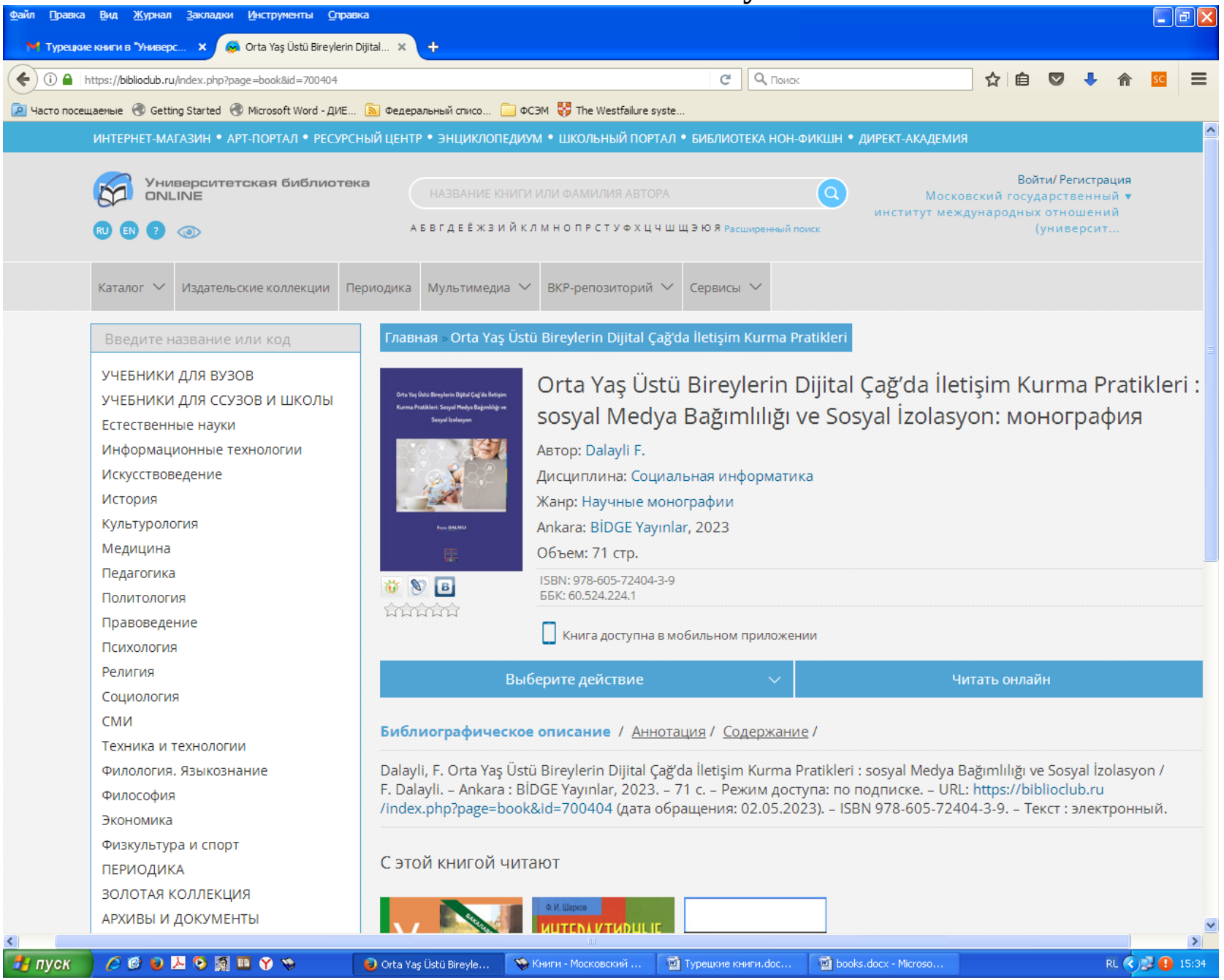

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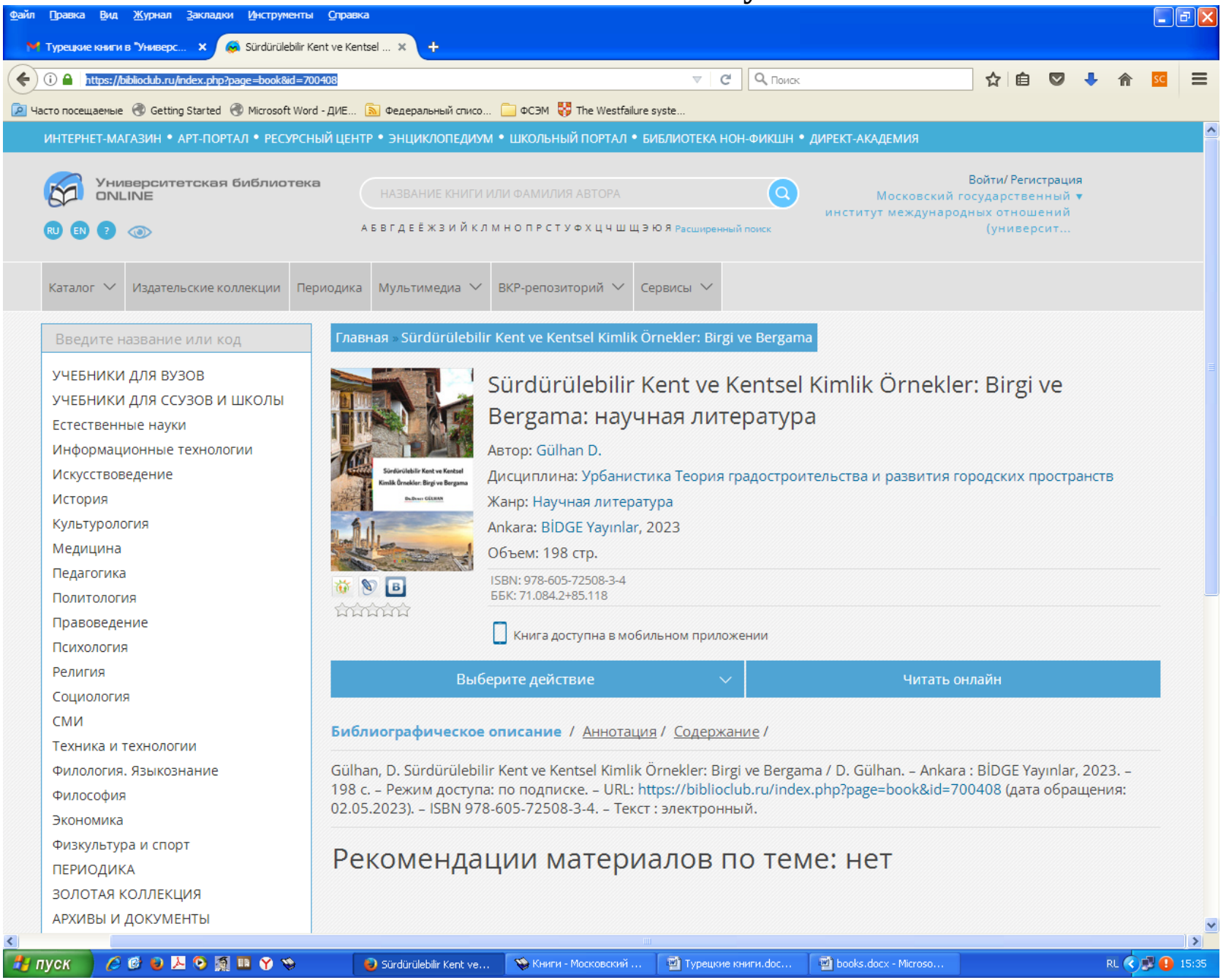

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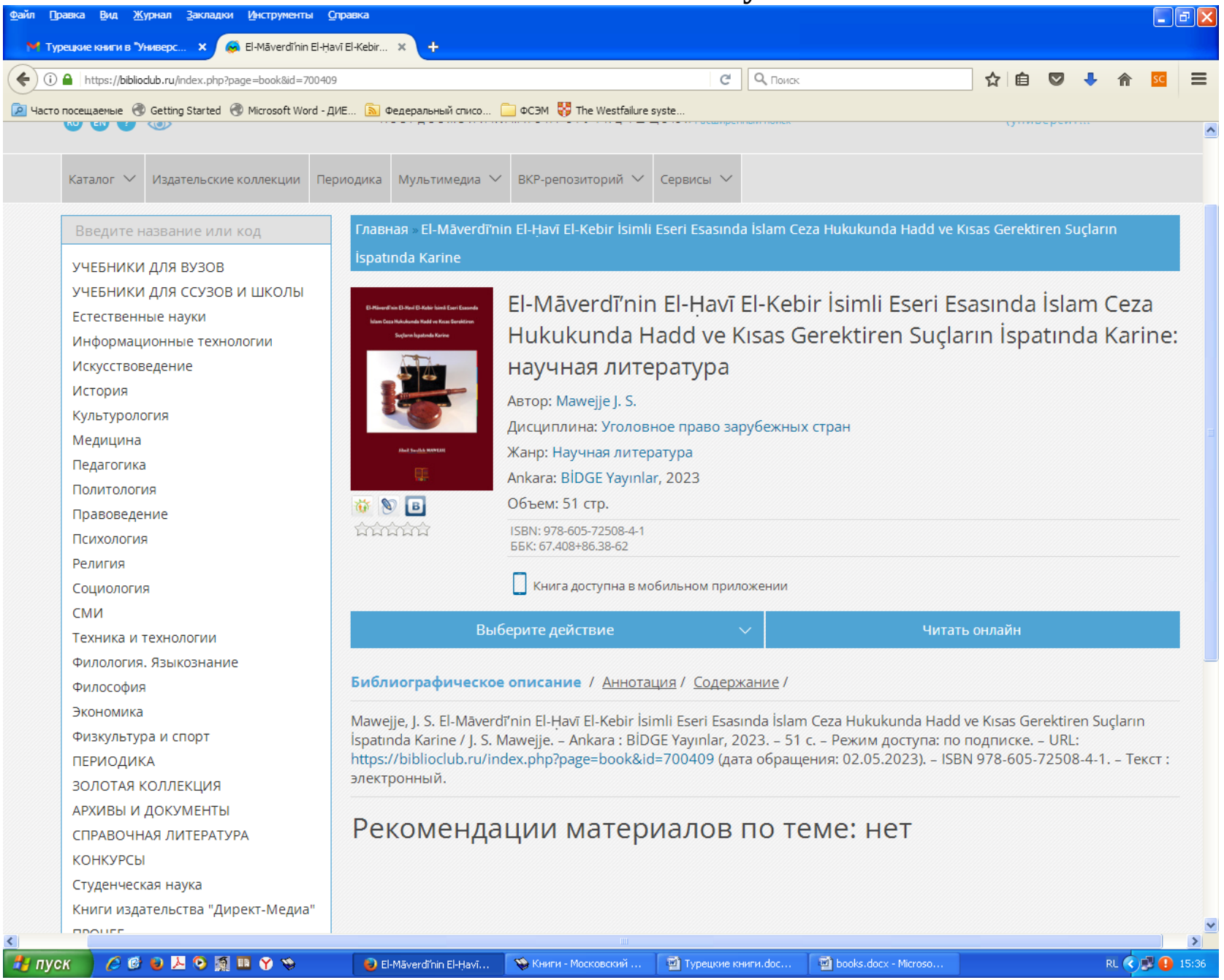

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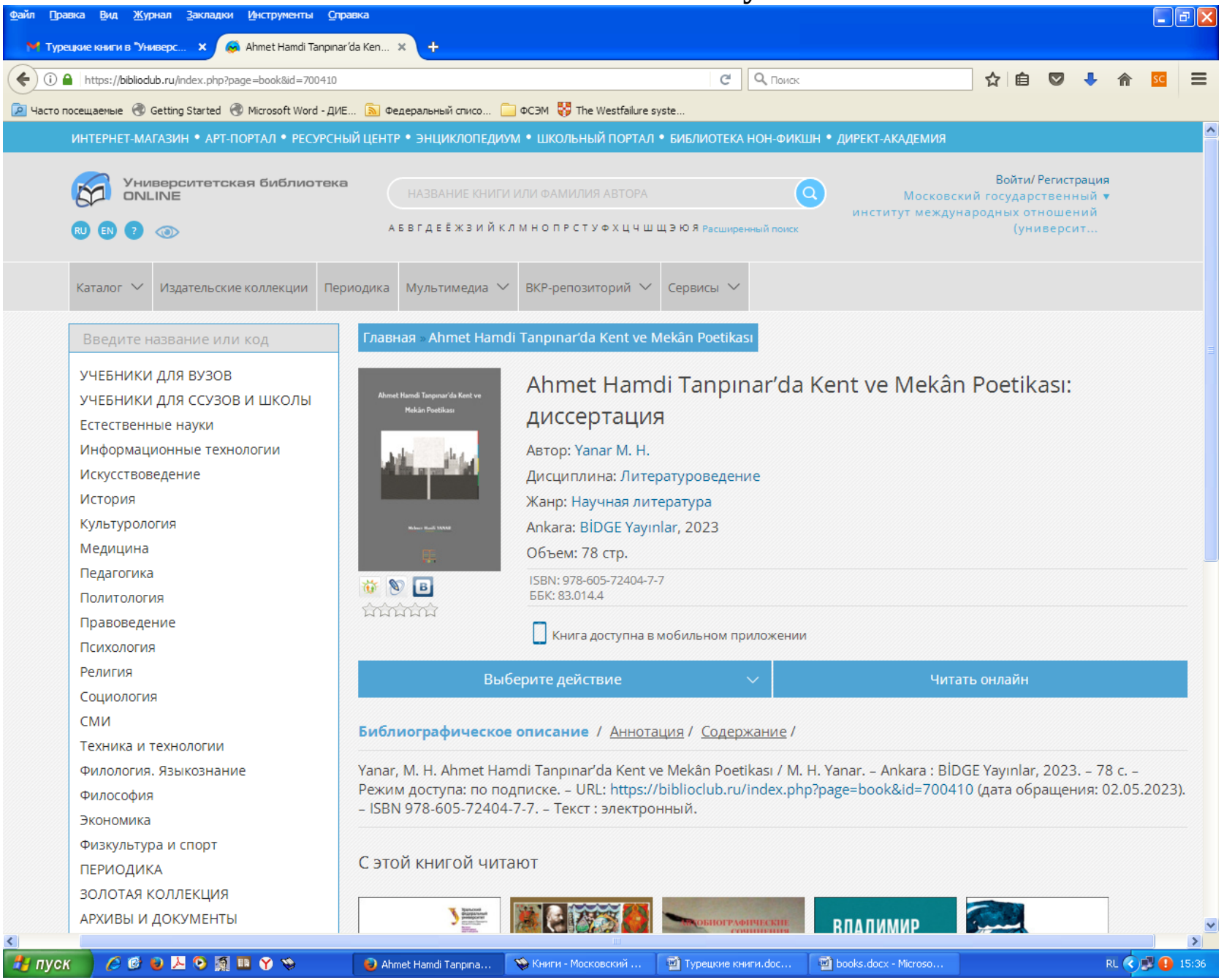

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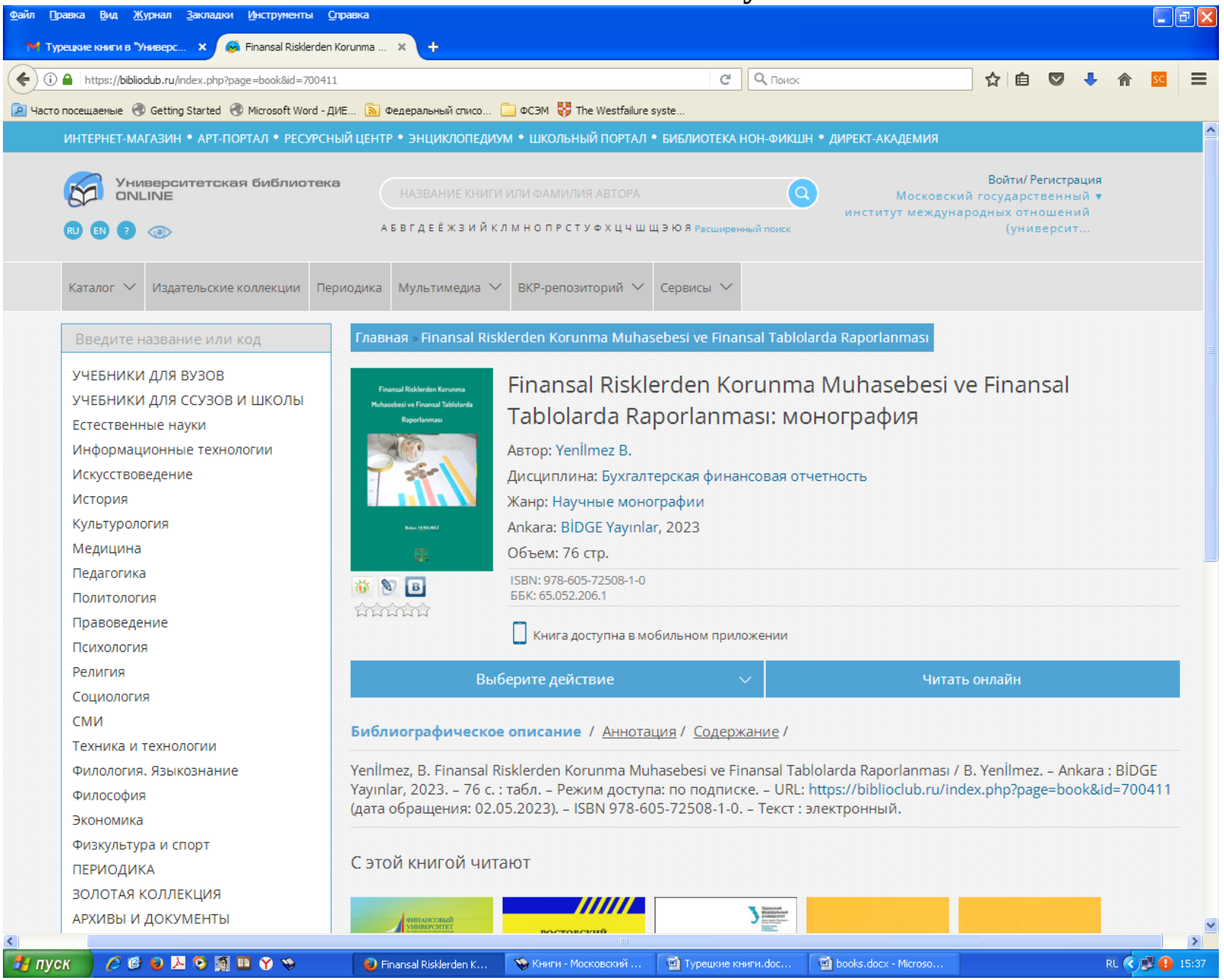

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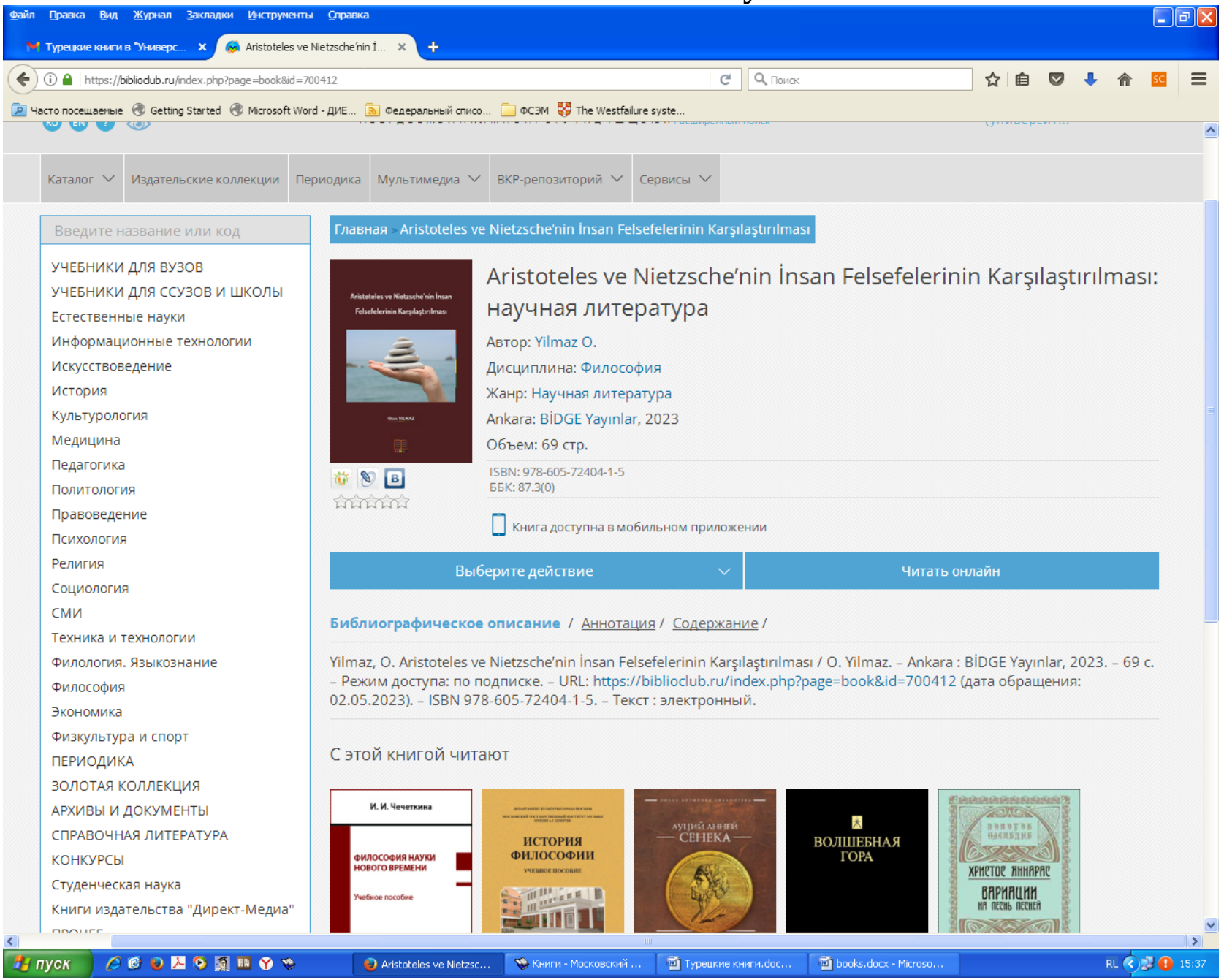

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