# Active versus Passive Teaching: Students' Perceptions and Thinking Skills

Evgeniy Terentev, Irina Shcheglova, Denis Federiakin, Yuliya Koreshnikova, Jamie Costley

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**Evgeniy Terentev** — PhD in Sociology, Director of the Institute of Education, HSE University. E-mail: eterentev@hse.ru. ORCID: https://orcid.org/0000-0002-3438-2786

**Irina Shcheglova** — PhD in Educational Sciences, Research Fellow, Institute of Education, HSE University. Address: 20 Myasnitskaya St., 101000 Moscow, Russian Federation. E-mail: ishcheglova@hse.ru. ORCID: https://orcid.org/0000-0001-5949-9617 (corresponding author)

**Denis Federiakin** — Researcher, Department of Business and Economics Education, University of Mainz (Germany). E-mail: denis.federiakin@uni-mainz.de. ORCID: https://orcid.org/0000-0003-0993-5315

**Yuliya Koreshnikova** — PhD in Educational Sciences, Researcher, Institute of Education, HSE University. E-mail: korehsnikova@hse.ru. ORCID: https://orcid.org/0000-0001-7566-0028

**Jamie Costley** — PhD in Education, Assistant Professor, College of Education, United Arab Emirates University (Al Ain, United Arab Emirates). E-mail: jcostley@uaeu.ac.ae. ORCID: https://orcid.org/0000-0002-1685-3863

Abstract

Most studies show that active teaching approaches positively affect student development when compared to passive teaching approaches. However, the literature is still unclear if an active teaching approach is more effective in all circumstances. This is because some studies find no differences in learning gains between the two approaches. Therefore, this study looks at how different levels of knowledge from Bloom's taxonomy are affected by the active versus passive teaching approach. The research was conducted with a group of students of economics and management. A validated standardized instrument to assess microeconomic and macroeconomic competencies (TUCE Test) allows us to model added value to the following cognitive levels: knowledge and understanding, explicit application, and implicit application. The cognitive levels are constructed in accordance with a revised version of Bloom's taxonomy. The results show that the active teaching approach is positively linked to academic performance at two cognitive levels: recognition and understanding and explicit understanding, with no significant relationship at the level of implicit understanding. On the other hand, a passive teaching approach has a negative relationship with academic outcomes at all the three cognitive levels.

Keywords teaching approaches, learning outcomes, economic competences, Bloom's taxonomy, cognitive diagnostic assessment

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The preparation of skilled graduates capable of self-learning and self-development has long been seen as one of the core missions of universities [Clark, 1983; Snellman, 2015]. However, over the past decades, questions have been raised as to whether traditional ways of knowledge dissemination commonly used in higher education allow fostering students' development [Barr, Tagg, 1995; Vrontis et al., 2007; Jensen, Bennett, 2016]. Some studies have shown that students are making rather modest learning gains or may even stagnate over the course of their studies [Arum, Roksa, 2011; Keeling, Hersh, 2012; Loyalka et al., 2021]. One possible reason for this lack of effectiveness of universities in training specialists is the application of teaching approaches which are ineffective in forming the skills required for varied demands of the modern knowledge society [Kálmán et al., 2020].

While there are many methods of defining competing teaching approaches, a common method of comparison is the distinction between the active and passive teaching approaches. These distinctions are key to understanding the effectiveness of teaching approaches and their impact on student learning [Barr, Tagg, 1995; Otting et al., 2010; Van Bergen, Parsell, 2019; O'Connor, 2020]. The active teaching approach is often associated with student-centered learning, whereas the passive approach — with traditional learning. There is a growing body of research that shows that active engagement of students into the educational process as co-creators of knowledge produces better learning outcomes than a more passive teaching approach [Joel, 2006; Krause, Coates, 2008; Miller et al., 2013]. However, the literature is still unclear if the active teaching approach is more effective in all circumstances, with some studies finding no differences in actual learning gains between the two approaches [Haidet et al., 2004; Miller et al., 2013; Deslauriers et al., 2019]. Furthermore, there is evidence that the effectiveness of the active approach depends on the learning context [Kirschner et al., 2006; Sweller et al., 2007; Matheson, 2008]. More specifically, in disciplines requiring students to retain much factually oriented background information (e.g., in medical sciences), the passive approach can produce better results [Matheson, 2008; Biesta, 2014]. Besides, some studies show that students in an active classroom learn more, but they feel like they learn less [Deslauriers et al., 2019].

## 1. Present study

Despite the plethora of research on the benefits of the active versus passive approach, there is a lack of clarity as to how differing teaching approaches affect learning at various levels of cognitive complexity. For this reason, the present study looks at how different levels of knowledge from Bloom's taxonomy are impacted by the approach used in teaching students of economics and management in a Russian university. To investigate this question, we use the data from the research project "The assessment of students' development of professional business and economic competencies", conducted at a Russian research-intensive university in 2020 as a part of the international comparative study aimed at measuring business and economic competences of university students. The two main parts of this study were an assessment of professional business and economic competences and a survey that examined students' opinions on the instruction approach.

This study contributes to the discussion about the pros and cons of the passive and active teaching approaches in the following ways. First, contrary to most previous studies, which drew on the results of self-reported measures of learning outcomes [Hartikainen et al., 2019; Shcheglova et al., 2019], we use a validated standardized instrument to assess microeconomic and macroeconomic competencies — the Test of Understanding in College Economics (TUCE) [Zlatkin-Troitschanskaia et al., 2014; Federiakin et al., 2022]. Second, this study contributes to our understanding of instruction and learning as it utilizes the methodological paradigm of cognitive diagnostic assessment [Sia, Lim, 2018], which allows to model the added values of cognitive levels. The TUCE is aimed at solving the significant problem with assessment of higher level learning outcomes; the latter are targeted by active learning methods and rather difficult to measure [Prince, 2013]. Third, we focus on the development of students' economic and professional business competences, which, despite being highly important due to the global economic change and increasing internationalization of markets, remain essentially under researched [Nagel et al., 2020].

The main research question this study aims to answer is how different levels of knowledge from Bloom's taxonomy are impacted by the approach students of economics and management (active versus passive.

Based on the above, the present study suggests two hypotheses:

- H1. Students who perceive the teaching approach as passive (focused on copying materials from the board and memorizing facts and formulas rather than using the information to solve problems) will perform better on the Recognition and Understanding dimensions of the assessment.

- H2. Students who perceive the teaching approach as active (focused on connecting teaching materials with practice, allocating time for discussions, and stimulating questions) will perform better on the Explicit understanding and Implicit understanding dimensions of the assessment.

## 2. Literature review

### 2.1. Active versus passive approach

There are several options for classifying teaching approaches. The authors of the present study relied on the classification proposed by Brooks & Brooks [1999], who identified two main approaches to teaching: passive and active. The key differences between active and passive approaches are in the way instructors work with students. For the passive approach, the main form of instruction is the lecture, and testing the knowledge acquired is often focused on the reproduction of a text [Barr, Tagg, 1995; Hamouda, Tarlochan, 2015]. Also, in the passive approach, when solving problems, students are given a ready-made algorithm, which they learn to reproduce [Prince, 2013]. Tasks are commonly not practice-oriented, and assessment process is focused on whether students have learned the necessary information. Therefore, teachers concentrate on transmitting the necessary materials and students often perform in a passive, receptive listening mode. In this approach, the teacher takes the leading position in the learning process, and seminars and exams are a key form of providing and assessing knowledge [Barr, Tagg, 1995]. The active approach requires the teacher to implement active-learning techniques and engage students in critical analysis, dialogue, and discussion, where students are active and engaged learners [Wulf, 2019]. Within the active approach to learning, the educational environment is built in an interactive manner, and tasks are practice-oriented [Prince, 2013].

Most current research into instructional approaches suggests that students who are taught using the active approach perform better compared to those taught through the passive one. [Maheshwari, Thomas, 2017; Deslauriers et al., 2019]. The active teaching approach fosters students' development and contributes to learning gains in general competencies, such as critical thinking and teamwork [Long, 2012]. Furthermore, the development of higher-order thinking skills becomes possible through this approach as its targeted outcome is what the student has learnt but not what he or she has been taught [Attard et al., 2010; Lavi et al., 2021]. More specifically, asking students to explain their views to others has been shown to have a positive effect on learning outcomes [Biesta, 2014]. Therefore, this approach has potential to prepare students for future career and personal life and also helps them adapt to economic and political changes [Hartikainen et al., 2019].

Although active learning is generally considered to be more effective, some studies show that active learning as a pedagogical approach may have a mixed effect (both positive and negative) on learning outcomes [Hartikainen et al., 2019]. These results seem to be context specific and provide evidence that a more passive approach works well for low-performing students, especially those from traditionally underrepresented STEM fields [Freeman et al., 2014]. Furthermore, unstructured tasks with multiple solutions can also be a challenge to students who have a low level of knowledge on a particular topic [Sweller, 1988]. As Sweller [1988] points out, high levels of cognitive complexity may cause cognitive overload and an active approach often requires higher cognitive engagement from students. Deslauriers and his colleagues also found that when students experience an increased cognitive effort associated with active learning, they initially take that effort to signify poorer learning [Deslauriers et al., 2019].

### 2.2. Taxonomy of cognitive complexity and teaching approaches

One way of understanding the levels of knowledge and how teaching approaches might affect these levels comes from the works of Bloom and his colleagues, who have suggested a universal classification system, which segments domains of learning within a taxonomy of cognitive complexity [Bloom et al., 1956; Anderson, Krathwohl, 2001]. Active learning draws on Bloom's higher order skills of analysis, such as synthesis and evaluation, and passive learning does on lower order skills, such as knowledge, comprehension, and application [Bloom, 1956, p. 18]. Studies conducted based on Bloom's taxonomy and its revised versions suggest that the skills needed at the knowledge level should be different from those needed at the synthesis and evaluation levels [Dong, 2014]. It may be the case that differing teaching approaches are more or less effective at increasing learning depending on the level of cognitive complexity within the taxonomy. For example, a more passive teaching approach could be more effective for the lower levels of Bloom's taxonomy — remembering and understanding, as a passive teaching method is often focused on the teaching of facts and isolated pieces of information [Branzetti et al., 2019]. However, a more active approach may be more effective at the upper levels of the taxonomy, when students need to start making connections among the facts and generating their own inferences and ideas within the context of the course [Tabrizi, Rideout, 2017; Bean et al., 2021].

There are myriad studies which show that problem-based learning and collaborative learning used by teachers within the active approach have a positive effect on academic achievements [Freeman et al., 2014; Deslauriers et al., 2019]. However, the majority of studies provide results for standard measures of academic achieve-

ment such as test scores. This study looks further and contributes to the understanding how different teaching approaches might have different effects depending on the level of skills utilizing a validated standardized instrument to assess microeconomic and macroeconomic competencies (TUCE Test).

## 3. Methods and data

The main points of investigation in this study were the relationships between students' perception of teaching approaches and students' actual performance on business and economic competencies. To test the hypotheses and answer the main research question, we used three data sources: (1) students' results of the TUCE test; (2) results of the student survey on their learning experience (with the focus on the perceptions of teaching practices); (3) students' background characteristics. Test data was collected in the spring of 2020 at a Russian research-intensive university as a part of the international project "The assessment of students' development of professional business and economic competencies" (WiWiKoM). The targeted sample was undergraduate students, enrolled in programs related to economics or management. Both the knowledge test and the survey were conducted online on the Moodle platform in the spring of 2020.

All students were invited to participate in the project by taking the test and answering the survey questions. The students were assured that the test results will not influence students' marks and the teachers will receive the results in a disaggregated format. Asynchronous proctoring system was used to control misconduct during testing procedures. No violations were detected. The questionnaire on student experience at university consisted of 25 questions focused on students' characteristics (gender, age, educational background, parents' education), their choice of university and educational program, learning experience with the main focus on the perceptions of teaching practices. 4,121 out of 6,921 students in the targeted sample (60%) completed the test and the survey. Among the students who took part in the study, 58.5% were female and 41.5% male. The average age of the students was 19.4 years old. The variable "participation in national contests" indicates whether students participated in any economics-related national contests or not. The participation in large-scale national contests gives students extra marks in the entrance exam. This information is regarded as the administrative type of data and it was provided by the university administration. The main characteristics of the sample are presented in Table 1. The missings do not exceed 4% of the sample. According to Tabachnick and Fide [2007], it should not impact the results.

Table 1. **Description of demographic variables**

| Variables | Description |
|---|---|
| Gender | 58.5% female and 41.5% male |
| Age | Mean = 19.4, SD = 1.190 |
| Father's education | 82.1% have a university degree or higher |
| Year of study | 29.1% — first-year students,<br>38.1% — second-year students,<br>32.8% — third-year students |
| Participation in National Contests | 11.83% — Yes<br>88.17% — No |

**4. Students' perception of teaching approaches**

To distinguish between different approaches used by instructors, students were asked the following question: "Considering the work of the majority of your teachers and your educational experience, to what extent do you agree or disagree with the following statements?"

*The passive approach*: 1) teachers expect that students will mainly copy material (from the board); 2) teachers emphasize the need to learn facts, formulas and the like; 3) teachers believe that it is more important to learn certain facts rather than how to use the information to solve problems; 4) 5) teachers expect students to take the presented information as unquestionable facts (Cronbach's Alpha = 0.82).

*The active approach*: 1) teachers connect teaching material with practice; 2) teachers concentrate not on memorizing facts, but on how well students understand the theory which explains the facts; 3) teachers allocate time for discussions; 4) teachers suggest that students ask questions and formulate hypotheses; 5) teachers ask students to solve non-trivial real-life tasks; 6) teachers encourage students to put into practice the knowledge and skills obtained in class (Cronbach's Alpha = 0.99).

The questions were based on the ideas of Brooks and Brooks [1999] and Barr and Tagg [1995], who contributed to the state of research on teaching and learning.

**5. The assessment of the development of students' professional business and economic competencies**

To assess the level of economic and business competency, we used the Test of Understanding of College Economics (TUCE) [Walstad et al., 2007; Walstad et al., 2013], which had been adapted to the Russian educational and cultural context [Federiakin et al., 2022]. The test allows evaluating the ability to apply economic principles to real-life problems, including public policy issues. The test items of the TUCE are classified in terms of sub-content domains (for example, Consumer Behavior or Fiscal Policies) and cognitive levels:

*"knowledge and understanding"*; "*explicit application"; "implicit application"*, constructed in accordance with the revised Bloom's taxonomy [Bloom, Krathwohl, 1956; Anderson, Krathwohl, 2001]. "*Knowledge and understanding"* is a combination of Bloom's first two categories. "*Explicit application" and "implicit application"* fall into the remaining three categories. "*Explicit application"* is the application of knowledge aligned with Bloom's taxonomy, and "*implicit application*" is analysis and evaluation (synthesis is not included in this typology).

To compile tasks, the content of the subject area of economics was divided into domains and subdomains. The differentiation of domains of the test corresponded to the general classification of subjects: microeconomics and macroeconomics. The subdomains included specific substantive categories, such as markets and prices or money and inflation. The selection of relevant content was based on a comprehensive analysis of documents, including analysis of curricula, as well as analysis of textbooks and expert interviews with teachers [Walstad et al., 2007; Walstad et al., 2013]. The more detailed information about the TUCE test and the WiWikom project can be found in papers by Zlatkin-Troitschanskaia et al. [2014], Federiakin et al. [2022].

## 6. The strategy of data analysis

To estimate the cognitive levels of economic competence acquisition according to the taxonomy of test items, we used Models for Cognitive Diagnostic Assessment [Sia, Lim, 2018]. The latter describe the cognitive state of each person in a random vector of dichotomous values, where 1 denotes mastery and 0 — non-mastery of the corresponding sub-competence. To apply CDM to our data, we used cross-classification of items in terms of their content sub-domains and cognitive levels. Thus, we viewed every cross-classification criterion as a separate sub-competence in CDM. This implies that each cognitive level is "purified" from the impact of items' content and from the impact of lower levels, allowing us to model the exact added value of each cognitive level.

The estimates of teachers' approaches were derived from item factor analysis [Wirth, Edwards, 2007]. This approach allows us to estimate students' true-score on surveys and directly regress cognitive levels' estimates on them. For the details of model estimation, see Appendix.

Then, we regressed the students' cognitive level estimates on the student estimates of teachers' approaches and individual-level factors. To consider the uncertainty in the discrete estimates of students' cognitive levels, we used logit-transformed Expected-a-Posteriori (EAP) estimates of the probability of a sub-competence acquisition:

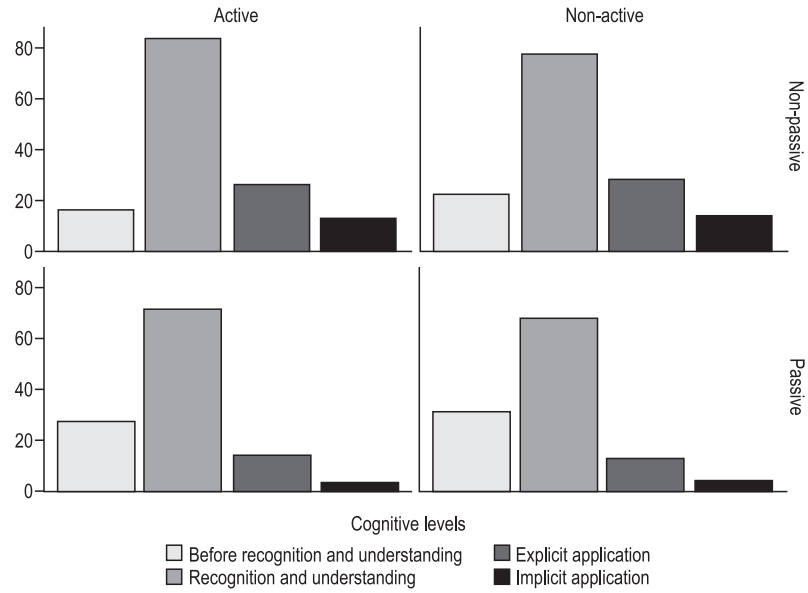
$$\text{logit}(EAP_{pk}) = \ln \frac{EAP_{pk}}{1 - EAP_{pk}},$$

where $EAP_{pk}$ is the probability of sub-competence $k$ being mastered by person $p$. As a result of using logit($EAP_{pk}$) instead of $EAP_{pk}$ as dependent variables, we received the two-step logistic regression.

## 7. Results

Drawing on our results, we received four categories of students: (1) those who see their teachers as combining the active and passive approaches (A+P+), (2) those who see their teachers as mostly using the active approach (A+P-), (3) those who see their teachers as mostly using the passive approach (A-P+), and (4) those who see their teachers as using neither the active nor the passive approaches (A-P-). The distribution of these categories in the overall sample is the following: the A-P+ category is the most widespread (43.9%), followed by A+P- (22.0%), A-P- (21.3%), and A+P+ (12.9%). The comparison of test results across the categories shows differences in shares of those who coped with tasks on different cognitive levels (Figure 1). The categories with non-passive teaching approaches (A+P- and A-P-) are characterized by the largest shares of students, who completed the tasks for the explicit application level (13%). At the same time, the categories with passive approaches (A-P+ and A+P+) demonstrated the largest shares of those who did not complete the tasks even for the recognition and understanding levels (31% and 28% respectively).

Figure 1. **Distribution of test-results based on teaching approaches**



To analyze the relationship between the teaching approaches and cognitive levels, we generated three regression models, using test scores on different cognitive levels as the dependent variables, and factor scores (derived from GRM) on the use of passive or active teaching approaches as independent variables, controlling for gender, year of study, the father's education and the results of national contests.

The results of the regression analysis showed that the use of different teaching approaches (passive or active) is related to different learning outcomes (Table 2). First, the use of the passive approach is negatively related to the test results for all the three cognitive levels — recognition and understanding, explicit understanding, and implicit understanding ($p < 0.001$). Thus, we did not confirm our first hypothesis about positive relationships between the passive teaching approach and students' achievements on the recognition and understanding dimensions of the assessment. Second, our results showed a positive relationship between the use of the active teaching approach and test results for the first two cognitive levels ("*recognition and understanding*", "*explicit understanding*", $p < 0.001$), with no significant relationship between the use of the active teaching approach and implicit understanding. Therefore, we only partially confirmed our second hypothesis about positive relationships between students' perception of the active teaching approach and students' achievements on the explicit understanding and implicit understanding dimensions of the assessment.

Table 2. **Regression analysis**

| Independent variable | Dependent variables | | | | | |
|---|---|---|---|---|---|---|
| | Level 1: Recognition and Understanding | | Level 2: Explicit understanding | | Level 3: Implicit understanding | |
| | Beta (SE) | Beta Standardized | Beta (SE) | Beta Standardized | Beta (SE) | Beta Standardized |
| Passive approach | –1.10*** (0.170) | –0.12 | –1.32*** (0.18) | –0.13 | –1.10*** (0.13) | –0.14 |
| Active approach | 1.08*** (0.16) | 0.12 | 0.92*** (0.17) | 0.089 | 0.13 (0.12) | 0.03 |
| Year of Study | 0.34* (0.17) | 0.03 | 0.31 (0.19) | 0.02 | 0.498** (0.15) | 0.05 |
| Gender (1 — Female, 0 — Male) | –2.52*** (0.28) | –0.14 | –3.59*** (0.31) | –0.17 | –2.24*** (0.24) | –0.14 |
| Father's education | 1.03** (0.37) | 0.04 | 1.27** (0.41) | 0.05 | 0.95** (0.34) | 0.05 |

| Independent variable | Dependent variables | | | | | |
|---|---|---|---|---|---|---|
| | Level 1: Recognition and Understanding | | Level 2: Explicit understanding | | Level 3: Implicit understanding | |
| | Beta (SE) | Beta Standardized | Beta (SE) | Beta Standardized | Beta (SE) | Beta Standardized |
| Results of national contest | 3.69*** (0.39) | 0.130 | 5.80*** (0.39) | 0.18 | 6.07*** (0.27) | 0.25 |

* $p < 0.05$; ** $p < 0.005$; *** $p < 0.001$.

## 8. Discussion

Despite the plethora of studies that highlight positive outcomes of the active teaching approach [Joel, 2006; Krause, Coates, 2008; Miller et al., 2013; 2017; Wulf, 2019], the passive teaching approach still dominates at many universities [Stains et al., 2018; Børte et al., 2020]. The current research supports the results of the previous studies, which point out that in general a few instructors implement active practices on a regular basis [Pithers, Soden, 2000]. Almost half of the students in the present study reported that their teachers used the passive teaching approach, showing that this issue is common in Russian higher education. The domination of the passive teaching approach can be related to the fact that many educational systems (including higher education in Russia) have been built on the teacher-centered model, which is based on passive methods, such as lectures and direct instruction, and where the primary role of the teacher is to impart knowledge to students. As this study dwells on the problem which is common to all educational systems, understanding the degree to which the passive or active teaching approach is more beneficial to different levels of student learning is of value for the field of higher education research.

The results of our study suggest that the passive teaching approach is not effective for any level of skill mastery. Moreover, it appears that the passive teaching approach does not help students develop even the lowest level of skill mastery (recognition and understanding). This result is of interest to the field of instruction, as it is commonly held that while the passive approach may not be effective for the higher levels of cognitive domains, it is at least beneficial at the lower levels of cognition [Hartikainen et al., 2019]. Notably, it can be productive when delivering information to a large number of students simultaneously as it requires fewer resources and can cover a broad range of content within a limited timeframe.

In contrast, the active teaching approach fosters higher levels of the development of two cognitive levels ("*recognition and understanding*", and "*explicit understanding*"). This result falls in line with

research suggesting that the active teaching approach is more effective than the passive one [Maheshwari, Thomas, 2017]. This may be due to the fact that the active teaching approach allows learners to access higher levels of self-regulation and engagement with the materials, which often leads to stronger and more sustained learning gains [Long, 2012; Biesta, 2014]. While the active teaching approach has shown mixed results in certain learning contexts and with certain levels of learners [Freeman et al., 2014; Hartikainen et al., 2019], the present study suggests that in our specific learning context the active approach is a more effective method of developing student learning for the knowledge domains of "*recognition and understanding"* and as well as "*explicit understanding*". However, as the results suggest, a rather small student population managed to reach higher levels of skills' mastery. In our sample, there is a small share of students (13%) who managed to reach the level of the *explicit application* and even fewer students acquired the highest cognitive level (*implicit understanding*) (7%). One explanation of the modest achievements of the students may be related to the complexity of the assessment materials used in the present study. They could have been too challenging for all learners regardless of the teaching methodology, which may have led to the fact that very few students reached the level of implicit understanding. Another explanation why this approach does not work can be related to the results of studies that point out that the active teaching approach has often been misinterpreted and misused by teachers and learners, resulting in learning practices that neither challenge students nor address their needs [Shah, 2019]. As the researchers found, teachers tend to adapt new initiatives to familiar practices, and slightly modify traditional teaching practices, not altering them fundamentally [Cuban, 2013]. Also, some researchers believe that the majority of teachers want their students to take notes rather than discuss material or place them in teams to work on a group project otherwise they think that they are not doing their job [Sprague, Dede, 1999]. It was shown that one-third of instructors who have tried active teaching eventually returned to passive instructions [Henderson et al., 2012]. Apart from that, some researchers have proved that receiving passive training first might have provided learners with a stronger task understanding that enhanced their active exploration [Klahr, Nigam, 2004; Deslauriers et al., 2019]. On the other hand, research on the concept of productive failure shows that allowing students to struggle with a task can lead to better uptake of subsequent instruction [Kapur, 2016]. Also, such factors as students' motivation and their approach to organizing their learning process can influence students' development. Besides, the active teaching approach suggests all students have the same level of background knowledge in the subject matter and are able to absorb the mate-

rial at the same pace [Lord, 2007]. However, the student population has become more heterogeneous than before. Students come to university from different socio-economic backgrounds and their level of education and abilities vary significantly [Quaye, Harper, 2014].

Although this study gives interesting insights into student learning and development in higher education, it has some limitations which we have to consider before implementing the results. The study utilizes students' perceptions of instructors' teaching approaches and refers to the majority of instructors at university. This can be contrasted with research that might look at instruction materials and classroom behavior to judge which instructional approach the instructor uses. Also, the study is based on the sample of one Russian university which has the status of a leading national research university. Therefore, the conclusions drawn from the data cannot be generalized to all Russian universities. Nonetheless, the results contribute to our understanding of how the active and passive teaching approaches work in our particular case.

## 9. Conclusion and practical recommendations

This study looks at student perception of teaching approaches and the relationships between those approaches and student performance at different cognitive levels. The results suggest that the passive teaching approach is ineffective at all cognitive levels, while the active teaching approach is effective only at lower cognitive levels. The results of this study suggest that the active teaching approach should be used in the context of higher education; however, the application of the active teaching approach may not be enough in and of itself to facilitate student success in reaching the highest levels of cognitive development. While not directly linked to the contents and context of this study, future research should certainly look into what methods universities can use to develop higher cognitive levels in their students. A possible direction of future research could be to look at those students who did reach the highest levels of cognitive development and reverse their study habits and/or the instructional practices they received.

Based on the results of the study and the existing literature, the following strategies can be used to foster student learning:

1. Individualised instruction. Given the heterogeneity of students' population, differences in their motivation and learning styles, individualised instruction can be used to improve students' response to being actively engaged in the classroom. Recognising and addressing the unique needs and learning styles of each student can enhance their development.
2. Experiential learning. Regardless of a field of study, students can take advantage of experiential learning, which creates op-

portunities for hands-on experiences and real-world applications of knowledge and foster practical skills.
3. Promoting curiosity and inquiry. Fostering a culture of curiosity and encouraging students to ask questions, explore, and seek answers independently can stimulate higher cognitive levels of thinking.

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**Appendix** To estimate cognitive levels, we used the Compensatory Reparametrized Unified Model (RUM) for cognitive diagnostic assessment [Rupp, Templin, Henson, 2010]. This model estimates probabilities of getting a specific item score for every respondent conditional on possessing a certain latent sub-competence profile. By contrast to the other popular models for cognitive diagnostic assessment, CRUM assumes that acquisition of every additional sub-competence entangled in an item increases the probability of solving it correctly. Moreover, each sub-competence has its own impact on probability, and this impact varies across items. This provides a partially-compensatory framework for decomposing composite abilities.

To estimate the absolute CDM fit, we used the averaged item Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Root of Squared Residuals (SRMSR), the average absolute deviation (MADcor) between the observed correlations and the model predicted correlations of item pairs, the averaged Q3-correlations of item residuals (MADQ3), and the average deviation of Q3-correlations from the MADQ3 (MADaQ3) [Lei, Li, 2016]. The results indicated a good model fit (Mean item RMSEA = 0.039; SRMSR = 0.017; MADcor = 0.014; MADQ3 = 0.014; MADaQ3 = 0.013). Additionally, no item demonstrated RMSEA more than 0.068, indicating a reasonably good item fit.

The results of modeling with CDM show that in total 25.6% of students have not mastered even the cognitive level of Recogni-

tion and Understanding, 74.4% of students have mastered the cognitive level of Recognition and Understanding, 19.4% of students have mastered the cognitive level of Explicit Application, and 8.1% of students have mastered the cognitive level of Implicit Application. These results suggest a rather low level of overall student economic proficiency. However, they are aggregated across all years of study. Since a detailed description and interpretation of these results lie far beyond this paper's scope, we do not discuss them any further. Also, these results introduce enough variance in the sample to allow for further analyses.

To model the relations of the cognitive levels with contextual variables, we use structural equation modeling [Little, 2014]. Particularly, we first built a confirmatory item factor analysis model for the confirmation of the survey structure (Figure 2). Then, we related these latent variables and several other control variables to the modified estimates of the students' cognitive levels (Figure 3). As seen from the figures,

Figure 2. **Initial first-step structural model used to establish factor structure of data**

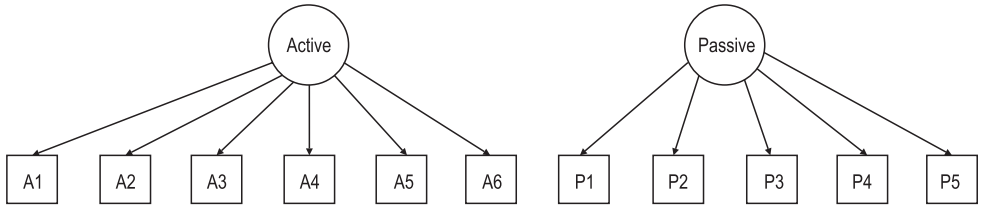
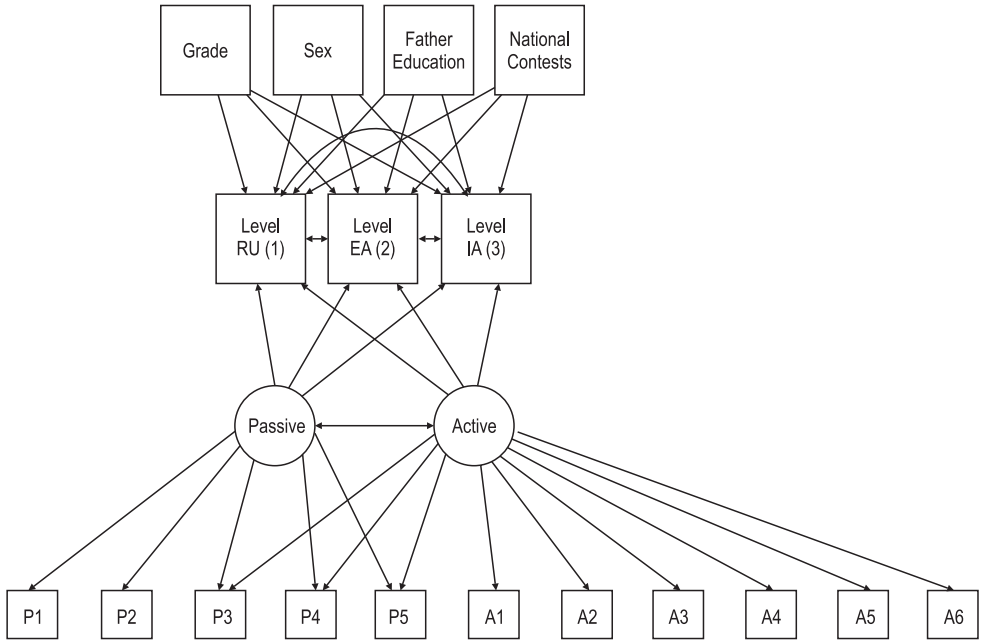



Figure 3. **Second-step structural model**



we assumed that the teaching approaches in question are not the opposite poles of a single continuum. In contrast, we assumed that the teaching approaches represent independent but correlated continua. Therefore, both of them can be employed by the same teacher.

To estimate the quality of the first-step model, we used widely accepted fit indices: RMSEA, the Standardized Root Mean Square Residual (SRMR), the Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) [Lacobucci, 2010]. The estimates of the quality of the first-step model are presented in Table 3.

Table 3. **Fit indices for models of latent variables**

| Statistics | Models | | | | |
|---|---|---|---|---|---|
| | Initial | Adjustments | | | |
| | | 1st | 2nd | 3rd | 4th |
| Chi-squared statistics for the baseline model | 117305.632 | | | | |
| Degrees of freedom for chi-squared statistics | 55 | | | | |
| Sample size | 4880 | | | | |
| Number of free parameters | 56 | 57 | 58 | 59 | 60 |
| Degrees of freedom for chi-squared statistics | 43 | 42 | 41 | 40 | 39 |
| Chi-squared statistics | 4093.563 | 2515.058 | 1836.088 | 1509.111 | 1246.044 |
| RMSEA | 0.138 | 0.109 | 0.094 | 0.086 | 0.079 |
| SRMR | 0.093 | 0.069 | 0.057 | 0.051 | 0.048 |
| CFI | 0.965 | 0.979 | 0.985 | 0.987 | 0.990 |
| TLI | 0.956 | 0.972 | 0.979 | 0.983 | 0.985 |

As Table 3 suggests, the initial structure of the model exhibited a poor model fit. We studied the model modification indices to improve it, which suggested a cross-load of Item 4 from the passive approach scale on both the active and passive approaches. We accepted this suggestion because, in our opinion, it reflects the structure of teaching activities in the sample: teachers are supposed to give both lectures and seminars, implying some amount of the passive approach in all teachers' activities. The factor loading of this item on both factors was positive and significant. However, this model adjustment was still insufficient. On the second step of the modification indices analysis, we added the cross-loading of Item 3 from the passive approach scale ("Teachers believe that it is more important to learn certain facts but not how to use the information to solve problems") on both the active and passive approaches. We interpreted this as an essential indicator of both teaching approaches. We assume that if

teachers rely heavily on making students memorize factual material, they, by definition, more intensively use the passive approach than the active one. The factor loading of this item was positive on the passive approach, negative on the active approach, and significant in both cases. Then, we added the cross-factor loading of Item 5 from the passive approach ("Teachers expect students to take the information provided as unquestionable facts") on the active approach. We interpreted this item as another key indicator of both the active and passive styles. Again, its factor loading was positive on the passive style and negative on the active style. Finally, we asses a residual covariance between Items 3 and 4 in the active style ("Teachers allocate time for discussions during classes" and "Teachers suggest students ask questions and formulate hypotheses"). This parameter reflects the fact that group discussions is one of the main forms of teaching, where students are capable of clarifying the issues they have with the course content. The standardized correlation of these item residuals is 0.41, which is statistically significant. As a result, we achieved an acceptable model fit. The final factor loadings are given in Table 4. All factor loadings are statistically significant.

| Items | Loadings of Students' Perception of Active Teaching Approach | Loadings of Students' Perception of Passive Teaching Approach |
|---|---|---|
| Teachers connect teaching material with practice | 0.823 | |
| Teachers concentrate not on memorizing facts, but on how well students understand the theory which explains facts | 0.819 | |
| Teachers allocate time for discussions during classes | 0.761 | |
| Teachers suggest students ask questions and formulate hypotheses | 0.82 | |
| Teachers ask students to solve non-trivial real-life tasks | 0.786 | |
| Teachers encourage students to put into practice knowledge and skills obtained in class | 0.762 | |
| The majority of my classes are structured the way that teachers deliver materials | 0.254 | 0.409 |
| Teachers believe that it is more important to learn certain facts but not to how to use the information to solve problems | -0.32 | 0.66 |
| Teachers expect students to take the information provided" as unquestionable facts | -0.169 | 0.607 |
| Teachers expect students to mainly copy material (from the board) | | 0.548 |
| Teachers emphasize the need to learn facts, formulas and the like | | 0.816 |

Then, we regressed the modified estimates of the students' cognitive levels on the constructed latent variables and other control variables. The model fit analysis results are presented in table 5. In total, the final model performed well, demonstrating a good model fit.

Table 5. **Fit indices for the model with cognitive levels**

| Statistics | Value |
|---|---|
| Chi-squared statistics for the baseline model | 96215.501 |
| Degrees of freedom for chi-squared statistics | 91 |
| Sample size | 4148 |
| Number of free parameters | 85 |
| Degrees of freedom for chi-squared statistics | 112 |
| Chi-squared statistics | 2326.982 |
| RMSEA | 0.069 |
| SRMR | 0.049 |
| CFI | 0.977 |
| TLI | 0.981 |

For the descriptive analysis, we split the factor scores on both continuums (the perception of teachers as using the active and passive teaching approaches) in means (at 0), discretizing the continua.

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