Attitude of students of computer science specialities to including computer simulators and business games in the academic progress

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***Abstract*— For the six years, students of several computer specialties of two Perm universities (a branch of the Higher School of Economics and the State University) have been evaluating the interest and usefulness of including computer simulators and business games in the educational process. The assessment is consistently high. The effectiveness of game forms is rated higher than traditional lecture-practical ones. The assessment does not depend much on such factors as the year of study, the classroom or distance form of the game, etc.**

Keywords*— *Computer simulator, business game, programming technology, software engineering, collective development of software systems, educational process, university.

I. Introduction

The use of business games in education has a long history, starting almost a hundred years ago [1]. Nowadays, business games and computer simulators are used in different fields of knowledge and for different age groups, including younger schoolchildren [1-13].

This paper considers the application of business games for training students in such areas as software engineering, business informatics, mathematical support of computer systems, information technology, etc. To train qualified programmers it is necessary to familiarize students with modern software systems development technologies, including studying methods of teamwork on the software project, organization of the project team, subject area analysis, software systems design, programming technologies, writing necessary documentation for software products, implementation methods etc., studying roles of team members, also their professional activity areas and duties during product development. The traditional form of lectures and seminars does not give sufficient effect in the study of these issues. Not only theory is needed, but also practice. The ideal would be to train students in the actual production process, but this is not possible for two reasons. The first is the impossibility of organising such internships for large numbers of students. There are not enough firms that would agree to do such a thing. The second reason is the difference between the goals of the learning process and those of the production process. For the production process, the main thing is the quality of the software product. For the learning process, it is the knowledge and skills of the students. Therefore, the training process may use situations which are better avoided in the real production process. Business games and computer simulators can be a salvation in this situation.

One of the authors of this article teaches at two universities in Perm: the Perm branch of the National Research University Higher School of Economics (HSE) and the Perm State National Research University (PSU). Among his students, there are representatives of different programming areas, different years of education, to whom he gives knowledge of modern software development technologies in different training courses. Various business games and computer simulators are used in the educational process. (For simplicity we will call all such training sessions "games"). After each game students are obliged to write a short essay (reflection) in which they comment on the form and content of the game and evaluate it by two criteria: interestingness and usefulness in terms of gaining professional knowledge and skills.

This paper analyses the reflections for 6 games, which were written by students during six years of teaching in game format in 2 universities. The aim of the study is to find out how students feel about the use of business games and computer simulators in teaching and to highlight the factors that influence their attitudes.

II. Materials and methods

Two universities took part in the study: the Perm branch of the National Research University Higher School of Economics and Perm State National Research University.

The study was conducted over a 6-year period. A total of 453 people participated in it. The information base of the study consisted of 2,194 objects.

A total of 323 first-year software engineering students took part at the Higher School of Economics. The games were part of the Introduction to Software Engineering discipline. Perm State University involved 130 third-year students in Applied Mathematics, Information Technology and Computer Security. The games were a part of the training course "Methods for Collaborative Development of Software Systems". In the course of the named training courses students learn about the programming technology and software product, modern popular technologies of software creation Microsoft Solution Framework for Agile (MSF) [14] and Scrum [15], stages of work on the software project, necessary activities and specialties involved in the work.

Students' reflections on six study sessions were analyzed. Namely:

- task to convert a program into a software product;

- three games on the different stages of software solution development according to MSF technology: the "Envisioning & Planning" stage, the "Stabilizing" stage, the "Deploying" stage;
- Scrum technology game ("Scrum Technology: Rituals and Artifacts");
- assignment to manage software projects when working with the IT Manager computer simulator.

"Converting a program into a software product" is a game where students are encouraged to create a software product, documentation and helpdesk. Although both universities study C# programming language and work in programming classes is done on Visual Studio platform, but students are allowed to create a program in any programming language. During the analysis of the reflections on this game, there was a lot of positive feedback. Students wrote that they enjoyed the task, as for many it was their first experience of working in a team. According to them, it became clearer that the work of a programmer consists not only of writing code, but also of other components, and there was an even greater desire to immerse themselves in the world of software engineering.

Two tasks - Envisioning & Planning and Scrum - are the usual "tabletop" business games. In the first game, students were divided into teams and studied the responsibilities of MSF project team members: Product Management, Program Management, Architecture, Development, User Experience, Test, Release/ Operations. They had to learn which role was responsible for what and what responsibilities they had at certain stages of product creation. The Scrum game involved an introduction to rituals and artefacts. The game artefacts (information objects) for the Scrum game were presented as Google documents. This ensured that the game materials were preserved and accessible to students at all times, both during and after the learning process. The other two, Stabilizing and Deploying, involve working with computer simulations at separate stages. Stabilizing" involves learning how to test the system for stability, while "Deploying" involves assembling information for deployment on the customer's side. Only one task, software project management, is based entirely on the software simulator. The latter game is oriented towards learning the iterative method of writing programs and for a closer acquaintance with the stages of creating software products.

All tasks are carried out in teams. This corresponds to the collaborative nature of work in all large software projects. In MSF and Scrum games, the size of the team depends on the requirements of the technology. In Envisioning & Planning a team consists of five to six people. In Scrum, the size can go up to nine. Teams of four to five people work on turning a program into a software product. For the other three tasks, Stabilizing, Deploying, and IT Manager, the team consists of two people. They can also be done alone, but from an educational point of view it is important for students to develop teamwork skills, so teamwork is assumed in all simulations. The two consecutive games "Stabilizing" and "Deploying" have the same team. This is important because the Deploying phase may reveal shortcomings made in the Stabilizing phase. Keeping the composition of the team means that problems in the Stabilizing phase will be solved by the same people who created them. In the other four games, the team is formed for one time.

Although the work was a team effort, each student wrote the reflections independently. Thus, the total number of reflections (with 453 participants and 6 games) could have been 2718. Unfortunately, not all students always do their homework, so there were actually 2194 reflections in the information base. The shortfall was almost 19%. As already mentioned, when writing a reflection, students gave the game two marks: for its interestingness and usefulness. According to the HSE standard, grades were given on a scale from 0 to 10. Grades of 8-10, translated into the standard school scale of 5, meant "excellent", grades 6-7 meant "good", grades 4-5 meant "satisfactory", lower grades were "unsatisfactory". The ten-point system allows for a more accurate reflection of student opinion than the five-point system.

Before giving marks, the students had to answer several questions. These questions were divided into two parts. Questions on the content of the game:

1. What was new?
2. What experiences have you had?
3. What did you learn?

Questions about the way the game was conducted:

5. Is the aim of the game clear?
6. Are the ways of achieving it clear?
7. How effective are they?
8. What did you like?
9. What didn't you like?
10. What was missing?
11. What needs to be changed in the game
12. How useful/harmful are these teaching methods compared to the traditional lecture-practice system?

Among other things, the answers to these questions often served as explanations and justifications for the value of the estimate given.

Statistical characteristics were used for analysis: arithmetic mean, frequency of different grades, median, etc. Calculations were made for both "interestingness" and "usefulness". Reflections were grouped according to different criteria: by universities, by the use of computer simulators, by the form of games (classroom/remote), etc.

Part of the results of the study have already been presented at narrower thematic conferences. For example, at the International Conference on Distance Learning in Minsk in May 2022, the difference in attitudes towards the face-to-face and distance games was discussed [16].

III. Research and Discussion

First of all, statistical characteristics were calculated for the whole set of reflections. Then the following parameters were taken into account in the analysis of the reflections:

1) university
2) course (year of study of the students),

3) the form of the game (classroom or distance),

4) the use of game software,

5) size of the team of students,

6) gender of the students.

Table 1 shows the average values of interest and usefulness for all data and for each university individually. Figure 1 shows how these indicators for the overall dataset changed dynamically over the study period.

TABLE I. SUMMARY SCORES FOR ALL TASKS

Parameter	Interest			Usefulness		
	PSU	*HSE*	*Total*	*PSU*	*HSE*	*Total*
Mean value	7,46	8,67	8,28	7,58	8,83	8,43
Median	8	9	9	8	9	9
Moda	10	10	10	8	10	10
Min	0	0	0	0	2	0
Max	10	10	10	10	10	10

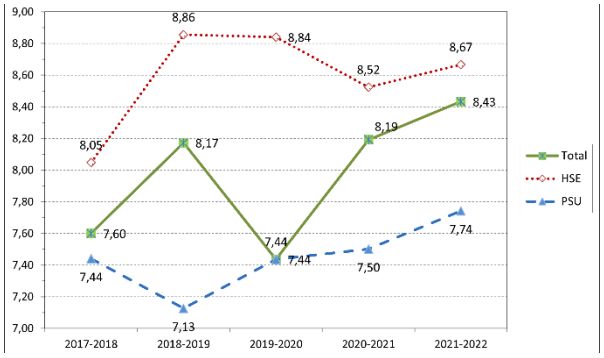

Fig. 1. Variation by year of the average values of interest

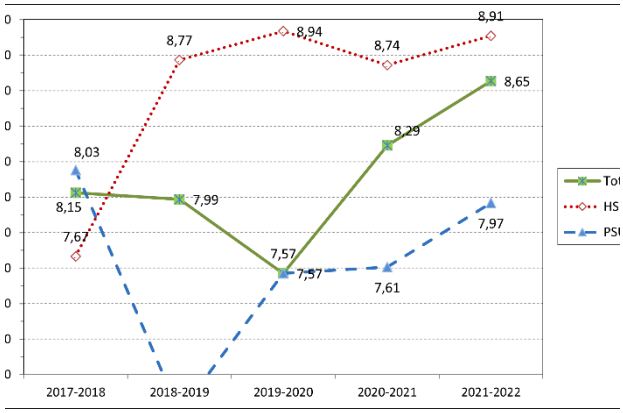

Fig. 2. Variation by year of the average values of usefulness

The table and the chart above show that students rate interest and usefulness of business games highly. According to the total data set, the mean score of interest is 8.28 and that of usefulness is 8.43. In both cases the median and mode are 9 and 10 respectively. So the highest score was the most frequent, although there were students who gave a score of 12 on a scale of 0 to 10. In their essays, students noted the greater effectiveness of business games compared to traditional lectures and practicums, and expressed a desire to see them more often in the learning process.

The diagrams of the dynamics of changes in the average scores show that over the six years of observation the scores for usefulness and interestingness tended to increase steadily. There was, however, a slight decline in the middle of the period. (The authors make no claim to an exact explanation for this decline, but it was in the spring of 2020 that the pandemic necessitated a switch to distance learning, which required an urgent adaptation of teaching methods, including business games. It was in the spring of 2020 that the methodology for distance learning business games was developed and tested, which could not but be accompanied by various errors).

What draws attention in Table 1 is the very wide variation in marks. Not only are the maximum scores equal to the maximum possible, but also the minimum scores equal to the minimum possible. This situation prompted a study of the frequency of occurrence of different marks. Table 2 shows the frequency of occurrence of the different values of interest and utility across the whole dataset and separately for each of the universities. Figures 2 and 3 group the grade values into three categories: low from 0 to 3, medium from 4 to 7, and high from 8 to 10. The frequency of occurrence of scores in each category in the whole dataset and separately for each university is shown.

TABLE II. FREQUENCY OF OCCURRENCE OF MARKS FOR ALL TASKS, %

Grade	Interest			Usefulness		
	PSU	HSE	Total	PSU	HSE	Total
0	0,87	0,00	0,39	0,87	0,00	0,39
1	1,01	0,00	0,45	0,29	0,00	0,13
2	2,02	0,35	1,09	1,45	0,35	0,84
3	3,61	0,23	1,74	2,75	0,46	1,48
4	3,90	1,16	2,38	4,49	0,46	2,25
5	7,37	2,78	4,82	6,67	2,08	4,11
6	7,66	4,51	5,91	8,12	3,69	5,66
7	16,47	9,03	12,34	15,65	8,65	11,76
8	21,24	19,44	20,24	23,91	16,26	19,67
9	14,60	20,95	18,12	13,77	22,15	18,44
10	21,24	41,55	32,52	22,03	45,91	35,35

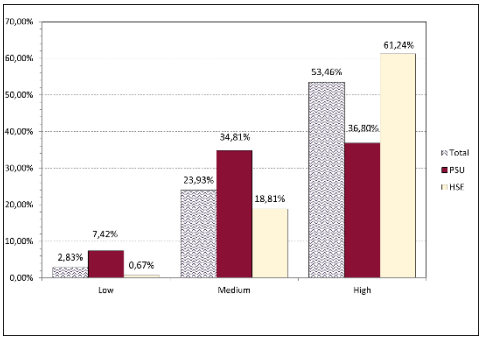

Fig. 3. The division of the interest scores into low, medium and high

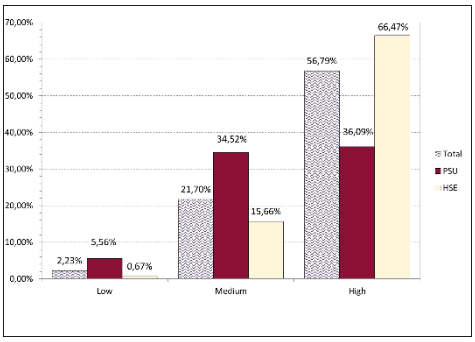

Fig. 4. The division of the utility scores into low, medium and high

In both indicators - interestingness and usefulness - high scores (8 points and above) absolutely dominate - 73.46%. Low grades (0 to 3 points) are few, for two universities only 2.83% of the total number of grades. To identify students' dissatisfaction, the reflections of students who gave low grades were analyzed. It turned out that students were not against the games themselves, and the reasons for dissatisfaction were of a more private nature. They were mostly dissatisfied with the quality of computer simulators, complexity of tasks, time spent on completing tasks or, on the contrary, lack of theory. All 'downward spikes' are seen as a crucial element of feedback signaling shortcomings. Increasing graphs of the dynamics of grades show the result of corrective work, because new more adequate simulations are constantly being developed and the methodology of the lessons is being improved.

The above charts and tables show that PSU students are more critical of games. Low grades for PSU students are an order of magnitude higher than those of HSE students, while average grades are twice as high. And high grades are a quarter less. The difference between the scores of students of the two institutions is stable at about 17% (1.3 points). For the interest index, it is 8.70 at the HSE vs. 7.45 at PSU. For usefulness, it is 8.85 at HSE and 7.56 at PSU.

The difference in the generalized scores prompted a comparison of the scores for the individual games. The results are shown in Figs. 5 и 6. The scores from PSU for all games are lower than those from HSE.

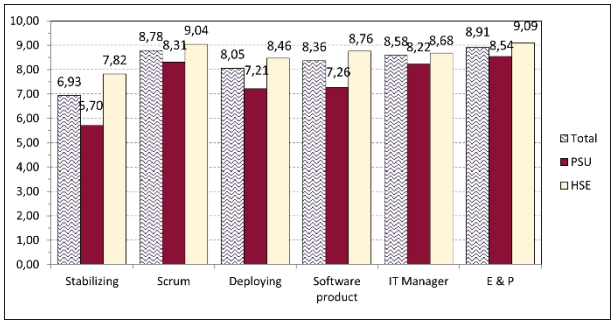

Fig. 5. Average interest score for the different tasks

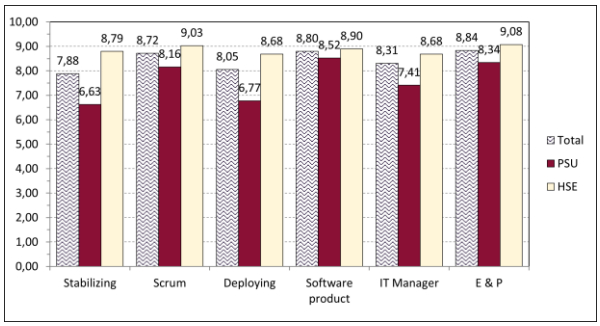

Fig. 6. Average Usefilness score for the different tasks

The study showed that the scores of PSU students were generally lower than those of HSE students due to the fact that they were students of different ages and experiences. The difference in curricula led to the fact that the games played by first year students at the HSE are played by third year students at PSU. For third year students the material was somewhat familiar, whereas for first year students it was completely new and therefore seemed more interesting and challenging.

All of the games considered were team games, but team size varied from game to game, so it was decided to test the dependence of student attitudes on team size in the games. The teams were divided into large teams (4-8 people) and small teams (2-3). Large teams were in Envisioning & Planning, Scrum and Software Product games, small teams in all other games. The average values of interest and usefulness are shown in Table 3. Although games with larger teams were rated higher than smaller teams, but both scores are high, so it can be assumed that the size of the team does not affect the students' attitude towards the game.

TABLE III. AVERAGE MARKS DEPENDING ON TEAM SIZE

Team size	Interest	Usefulness
4–8 people	8,60	8,68
2–3 people	7,64	7,82

There was also a pandemic period at the time of the study. Some games were converted to a remote form and some were not changed at all (e.g. the computer simulator "IT Manager"). But two - Envisioning & Planning and Scrum - required the development of fundamentally new techniques. The question arose: does the format of the game - remote or classroom - affect students' attitudes to such games? Average values of interest and usefulness are given in Table 4. The evaluations do not differ significantly. Classroom games were given an average score of 8.5, while remote games were given an average score of 8, so it can be assumed that the format of the games does not affect the attitude of students.

TABLE IV. AVERAGE INTEREST AND USEFULNESS MARKS DEPENDING ON THE FORMAT OF THE GAMES

Team size	Interest	Usefulness
Distance	8,33	7,21
Classroom	8,51	8,55

All games have been divided into three categories according to the use of computers:

1) computerless;

2) with partial use of a computer (part of the work, sometimes the main work, was done without a computer; computer programs were used at some stages);

3) computer-based simulations.

The first category included two computerless games ("Envisioning & Planning" and "Scrum"), the second category included three “part-digital” tasks ("Stabilizing", "Deploying" and "Converting program to Software Product") and the third category included one simulation ("IT Manager").

The question arose as to whether the presence of a software component in the game influenced students' attitudes. The average values of interest and usefulness for each category of games are shown below in Table 5. It turned out that the most interesting games are those in which no computer components were applied, but they are not too superior to computer simulation games. The games with partial use of the computer had the lowest scores. But they also lag behind non-computer games by only 1.2 points for interest and 0.65 points for utility. It can be concluded that the presence of a computer component does not affect the attitude of students to the game.

TABLE V. AVERAGE INTEREST AND USEFULNESS OF GAMES DEPENDING ON THE PRESENCE OF A COMPUTER COMPONENT IN THE GAME

Game Category	Interest	Usefulness
All games	8,28	8,43
Computerless games	8,85	8,79
With partial use of the game computer	7,73	8,22
Computer simulation games	8,58	8,31

Table 6 and Figures 7 and 8 present the gender aspect of the study. The table and diagrams show that students' perception of business games and simulations does not depend on gender. Women's scores are not much higher than men's for interestingness (no more than 0.5), and for usefulness (no more than 1). For 6 years of games we can see that scores for usefulness were slightly higher for both sexes, but, on the whole, both are rather high.

TABLE VI. AVERAGE INTEREST AND USEFULNESS OF GAMES ACCORDING TO STUDENT GENDER

Task	Interest			Usefulness		
	All	Women	Men	All	Women	Men
Stabilizing	6,93	7,08	6,87	7,88	7,99	7,84
Scrum	8,78	9,03	8,68	8,72	8,87	8,66
Deploying	8,05	8,34	7,95	8,05	8,28	7,97
Software product	8,36	8,46	8,32	8,80	8,85	8,78
IT Manager	8,58	8,70	8,54	8,31	8,61	8,19
E & P	8,91	8,98	8,88	8,84	8,99	8,77

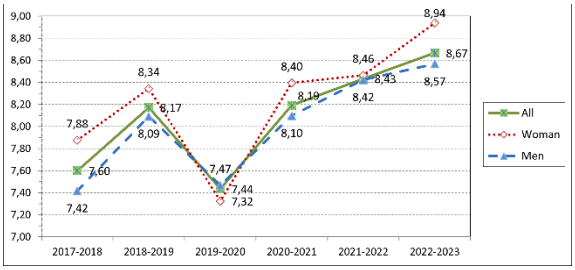

Fig. 7. Average rating of game interest depending on the gender of the student

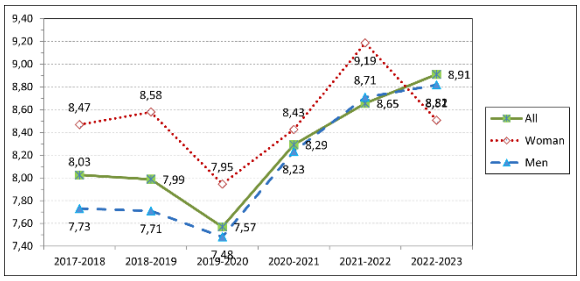

Fig. 8. Average rating of game usefulness depending on the gender of the student

IV. CONCLUSION

The aim of the study was to determine students' attitudes towards the use of computer simulators and business games in the learning process and to identify reasons for dissatisfaction, if any. The material of the study was observations of students from two Perm universities collected over a period of six years and concerning six games.

It turned out that the form of business games is evaluated by students as a format superior to the traditional lecture-practice system. In the reflections the majority of students said that such sessions deserved a wider application, but that they could not fully replace lectures. It was noted that it is an excellent format for reinforcing the theoretical knowledge gained in lectures and for gaining practical skills.

Over the 6 years of observation, it was found that grades are trending upwards slowly, although there was a decline in the academic year 2019-2020. The grades of students in 2022-2023 increased the calculated characteristics of the average by 0.2. Overall, student perceptions were not influenced by factors such as computer component, class

format, team size, and gender of respondents. The most significant factor was the students' year of study. Third-year grades were significantly lower than first-year grades, which was explained by the fact that the former had already had some practical experience and were somewhat familiar with the material being studied. After the graduate survey, a third of the respondents said that the knowledge gained in such classes was useful for them when working in real firms, and that it was easier for them to adapt to the work environment, as they had already gained some work experience in the classes.

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