Students Academic Achievement Assessment in Higher Education Institutions

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Abstract. Students academic achievement assessment in higher education institutions is one of the most urgent tasks that teachers face in the role of organizers of the educational process. The problem of forming a correct and objective rating point in assessing the results of studying a discipline is the key point in the final stage in studying thematic and module parts of the material. The rating score is formed by assessing individual student's educational activities. Depending on the type of assessment and control the students' vision of assessment objectivity is different.

This study analyzes the works of Ukrainian and foreign authors who have devoted their scientific research to studying the question of students' learning outcomes control and evaluation; highlighting the principles of formative assessment and the peculiarities of distance learning assessment tasks formation.

Particular attention is paid to the development of the author's methodology for educational achievements assessment for future bachelors of computer science. The contents of Bloom's taxonomy levels are discussed, as well as the explanation of the types of activities for the assessment system, for example, the design of practical tasks of the discipline "Algorithmization and Programming" (C ++ programming language) of the specialty "Computer Sciences", which is being studied in the first year by future bachelors of computer sciences.

Keywords: students academic achievement assessment, Bloom’s taxonomy, assessment rating system

1 Introduction

Each year in Ukraine, higher education institutions with IT-specification training prepare a sufficient number of IT branch bachelors, in particular, future bachelors of computer science who are in extreme demand in the domestic IT job market.

But there is enough evidence that only 25% of IT-specification graduates can find employment in an IT company, while other graduates do not meet the requirements which are put forward by the employers while headhunting.

Which remains important is the question of improving the quality of professional training for future bachelors of computer science, of their level of professional competence, and in particular, their IC competence, so that it could meet the IT market current requirements, global needs as well as employers' requirements [1, p.11].

Nowadays in our country there is still no single educational toolkit that allows measuring and assessing the outcomes of the learning process as well as the level of competency acquired, although there are examples of such tools on international level (for example, TIMSS, PISA, CIVIC Education Project) which Ukrainian students can use as well, if they are willing to [2, p.154].

The improvement of forms and methods aimed at creating a coherent system of continuous education allows to develop a unified system for assessing the dynamics of development motion for bachelors of computer sciences in their educational activities

2 Research Results

The following methods were used in the research process: theoretical - studying and analysis of pedagogical, methodical and scientific literature; modern scientists studies results analysis to find out the state of the problem; observational - educational process observance; praximetric - study and analysis of curricula, educational documentation, programs and results of student activities as well as research methods such as surveys, questionnaires, teacher interviews, methods of comparative analysis and statistical data processing.

Theoretical and practical issues of the assessment system organization for academic students achievements in higher education institutions are covered in the works of V.M. Bocharnikova [3], V.M. Kukharenko [8], S.G. Lytvynova [9], M.I. Tomilova, Ye.Yu. Vasilyeva, O.A. Kharkova [4], L.M. Ognevchuk [2], B.Ye. Starychenko [7] and others.

However, special attention needs to be paid to the issues of procedural, technological, motivational support for the assessment of the academic achievements of students in higher education institutions as a coherent pedagogical system that takes into account individual interests, abilities and inclinations.

3 Research Results

New technologies introduction into the educational process in higher education institutions leads to the emergence of new unconventional forms and methods of assessing the educational attainment of students in higher education institutions. In the framework of our study, we consider the research of scholars in relation to students educational achievements assessment, in particular future bachelors of computer sciences.

On one hand we can see, according to V.M. Bocharnyk the assessment, which is carried out in the course of students' educational achievements control, stimulates them to active educational and cognitive activity, and therefore, acts as a learning factor, which determines positive results of the educational process [3, p.23].

On the other hand there is a substantial subjective part to it - M.I. Tomilova, Ye.Yu. Vasilyeva, O.A. Kharkova investigated the issues of students’ perception of knowledge assessment done while realizing studying activities in higher education institutions. They came to the conclusion that students differently evaluate the objectivity and fairness of their knowledge assessment. Most students highly rate the objectivity of their knowledge assessment in an oral questionnaire or interview, but one in ten felt that the results did not correlate with the real level during tests. Most students praised the objectiveness and fairness of the point-rating scale. More than half of the students (59%) rated the degree of external factors (mood, attitude to the teacher) influence on the process [4, p.30].

Students’ evaluations of the assessment they get are not the only thing that diverges, but also the system of assessment making itself as well.

Foreign authors S.A. Borodich, A.N. Teplyakovskaya, comparing the problems and perspectives of the point-rating system (PRS) of student knowledge assessment at universities in Russia and Belarus, conclude that in Belarus PRS is practiced only as a system of ten-point rating basis and only in face-to-face classroom education. Russian universities adopted a PRS of maximum points in a discipline of 100 points. These are scored for: intermediate attestation (credit or examination) - 40 points and other 60 points are achieved by the student during current and boundary control of knowledge build up during the semester educational process [5, p.139]. It is worth while noting that in the first year at university students have different starting points due to different conditions of studying in schools and the divergences of goals of educational process subjects.

Ukrainian higher education institutions have also adopted the system of 100 points rating for the students’ achievements in one discipline. An example of this is the provision on the rating system for evaluating the learning outcomes of NTUU " I. Sikorsky Kyiv Polytechnic Institute” [6].

B.Ye. Starichenko, a Ukainian expert, proves that obtaining a disciplinary rating score is possible and that its basis is the evaluation of all separate student's educational activities, provided by the discipline study plan. After calculating the average share of performance across all activities, it is reduced to a 100-point scale, which is a disciplinary rating [7, p.205].

A system for evaluating the educational achievements of higher education institution students based on a competency-based approach was proposed by L.M. Ognivchuk in her works. She also observed the fact that in other countries experts traditionally identify three main approaches to defining and putting into practice a competence interpretation to the quality of learning outcomes: a behavioral approach (USA), a functional approach (UK) and a multidimensional and holistic approach (France and Germany). These approaches appeared independently from each other first in the United States, then in the United Kingdom, and most recently in France and Germany [2, p.155].

A many year research into the issues of distance learning technologies introduction brought V.M. Kukharenko to the conclusion that at this stage of development of scientific approaches to students' academic achievement assessment, special attention has to be paid to the formative assessment which was adopted [8, p.53].

Another Ukrainian researcher S.G. Litvinova agrees with V.M. Kukharenko. In her work she notes that it is possible to increase the efficiency of control and assessment of students' knowledge with the help of formative assessment. In the present study we agree with her view that formative assessment is used by teachers to obtain data on the current state of students knowledge level in a particular topic as well as to identify next steps that should be taken to improve them [9, p.112].

The authors of this research clearly believe that benchmarking is needed for successful assessment organization as well as points that will allow evaluating the assessment system itself working properly.

Periodicity, educational and cognitive activity motivation, as well as individualization and differentiation can be seen as indicators of the didactic effectiveness of educational achievement formative assessment.

The peculiarities of formative assessment lie in the fact that it is student's strive in realization of his/her educational goals, which is assessed but not his / her personality. A clear algorithm for determining the grade is offered, which is mase understandable for the student; the focus is on the student's personal progress rather than the assessment. The following forms of students progress formative assessment of are offered: reflexive techniques (hand signals, card signals) to clarify and identify complex issues; clarifying questions; analytical questions; mini-tests; checking creative work for error detection etc. [9, p.112]. Among the features are: training, stimulating, controlling.

Considering the positive experience of the teachers of the National Technical University "Kharkiv Polytechnic Institute", in particular V.M. Kukharenko, in conducting an experiment on the use of Bloom's taxonomy to evaluate students' academic achievement, we will apply this approach to develop authors' methodology for evaluating academic achievement of future bachelors of computer science.

The authors of this article would like to point out that this approach is the basis for the control and assessment unit of the model of professional competence formation for future bachelors of computer science. Programming students knowledge level assessment is carried out using Bloom's taxonomy, which contains 6 levels of difficulty. Each practical task will correspond to its level with a certain number of points [10, p.110].

What should be taken into consideration when forming this model's control unit is that the employers put high requirements to employees, and the level of knowledge and skills of the graduates does not meet these requirements, as their education has mostly theoretical nature. This, in turn, requires constant correction of curricula and subjects taught in higher education institutions, as well as regular personnel retraining [11, p.85].

While assessing the knowledge level, substantial attention is paid to monitoring the work results of future bachelors of computer science, as an integral part of educational process, which is aimed at providing "student-teacher" feedback and to identify the basis of its correct organization [12, p.10].

Tasks formation of is carried out in accordance with the spheres of cognitive (Cognitive Domain), emotional (Affective Domain) and motor (Psychomotor Domain) goals. Cognitive goals cover everything related to knowledge acquisition and mental skills development. Emotional goals include all tasks related to values formation, relationships, students' emotional self-control development. Motor goals embrace motor skills development, as well as physical endurance [13, p.89], [14], [15].

While drawing up practical tasks, particular attention is paid to the field of cognitive goals, which is divided into the following six levels:

1. Remembering (Knowledge Level) – lower level.
2. Understanding (Comprehension Level).
3. Implementation (Application Level).
4. Analyzing (Analysis Level).
5. Assessment (Synthesis Level).
6. Creation (Evaluation Level) – higher level.

This is a classification of thinking, which is organized according to complexity levels and gives teachers and students the opportunity to learn and act in informational and educational space, provides a simple structure for many types of questions [13, p.98].

For example, we consider the content of Bloom's taxonomy levels with the definition of activity (verbal form) for designing practical tasks of the discipline "Algorithmization and Programming" (C++ programming language) specialty "Computer Sciences", which is studied in the first year by future bachelors of computer Sciences (Table 1).

Table 1. The content of student’s activity (verbal form) during practical tasks realization according to Bloom’s taxonomy

Bloom’s taxonomy levels	Level Contents	Definition of student activity (verbal form)
Remembering Level (Level 1)	All entry-level goals are formulated in practical reproduction examples. It is enough to acquaint students with theory and relevant practical examples so that they can repeat it in their programs	Show, characterize, adhere to a code design standard (coding standard, programming style), program code lines explanation by means of a comment
Understanding Level (Level 2)	In order to demonstrate the practical achievements of the understanding level (comprehension), programmer students have to: – draw up a block diagram of a simple task algorithm; – implement the algorithm in the form of a program code (compilation without errors); – apply the acquired knowledge in the program code into specific simple tasks (information is remembered and processed individually).	Compile, implement, describe, explain, anticipate, define, evaluate, adhere to the standard of code design (coding standard, programming style). Explain code lines using the comment

Implementation Level (Level 3)	In the Implementation level a student-programmer must fully demonstrate practical achievement of the Comprehension Level (Level 2). In addition, solve, execute and display a program code with advanced levels of complexity and functionality of previous-level practical tasks	Apply, demonstrate, count, execute, illustrate, show, solve, test
Analyzing Level (Level 4).	The goals of the Analyzing level (analysis) assume that programming students are able to: – analyze the task; – perform decomposition of the task (partitioning into separate simple tasks); – draw up a general flow chart of the algorithm and sub-task flow charts based on decomposition; – implement the algorithm of complex practical tasks in the form of a program code using functions	Analyze, decompose Execute complex practical tasks algorithm (write a program code)
Assessment Level (Level 5)	At the level of synthesis (assessment), students-programmers must fully demonstrate practical achievements of the Analyzing level (level 4). In doing so, solve, execute and display program code with increased levels of complexity and functionality of previous level practical tasks	Combine, integrate, modify, reposition, replace, plan, create, design, invent, anticipate (what if?), assemble, formulate, prepare, generalize, rewrite
Creation Level (Level 6)	At the sixth level, programming students demonstrate: – application of the studied material as a tool in solving complex problems of different directions (logical, mathematical, physical, metric, etc.) – performing the decomposition of the task (partitioning into separate simple tasks),	Evaluate, decide, classify, sort, control, measure, recommend, persuade (assure), select (select), judge (evaluate), explain, distinguish (recognize), support, conclude (finish), compare (compel), summarize.

	– drawing up a general flow chart of the algorithm and a flow chart of the subtasks, – application of the first paradigm of object-oriented approach - encapsulation (presentation of the program code in the form of 2 separate files: interface file (.h-file) and implementation file (. spp-file)) – algorithm implementation with the use of functions	

The authors offer an educational achievements assessment rating system using Bloom’s taxonomy levels which is represented in Table 2.

Table 2. Student educational achievements rating system using Bloom’s taxonomy levels

Levels	Levels by Bloom’s Taxonomy	Rating	Credits ECTS	Credits ECTS
6	Creation	95-100	A	perfect
5	Assessment	85-95	B	very good
4	Analysis	75-85	C	good
3	Implementation	70-75	D	very satisfactory
2	Understanding	65-70	Dx	satisfactory
1	Remembering	60-65	E	sufficient

In addition, each level of Bloom's taxonomy is subdivided into the following sub-levels: practical assignment accomplishment and defence, practical assignment accomplishment quality, term of delay (deadline non-meeting) for a practical assignment accomplishment.

The score of each sub-level may be reduced / increased. In order to determine the percentage reduction / increase in the resultant evaluation of each sub-item, a survey was conducted with 76 teachers from 23 regions of Ukraine and the city of Kyiv participating.

The results of the survey, namely the percentage reduction in the resultant evaluation of each sub-level, are presented in the form of diagrams and are shown as follows: practical assignment accomplishment - Fig.1, practical assignment accomplishment defence - Fig.2, the term of delay (deadline non-meeting) for a practical assignment accomplishment - Fig.3.

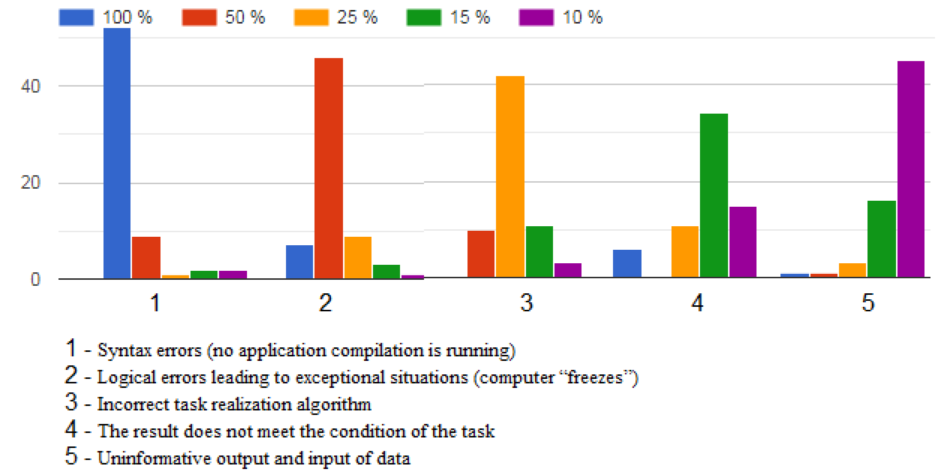

Fig. 1. Practical assignment accomplishment

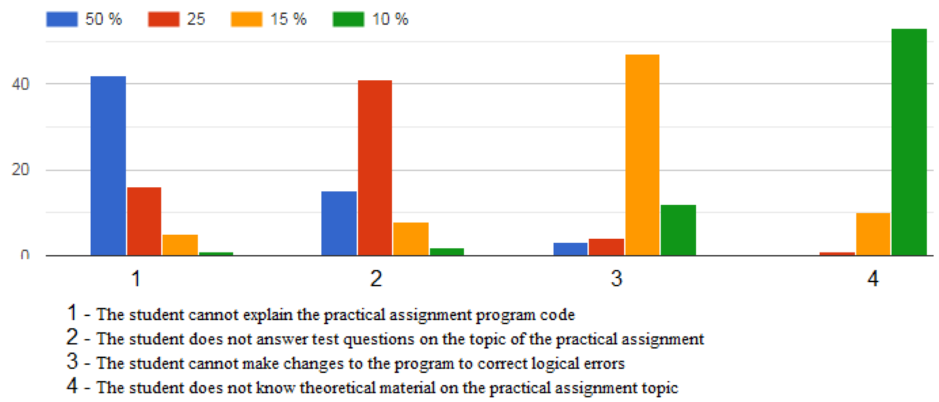

Fig. 2. Practical tasks defence

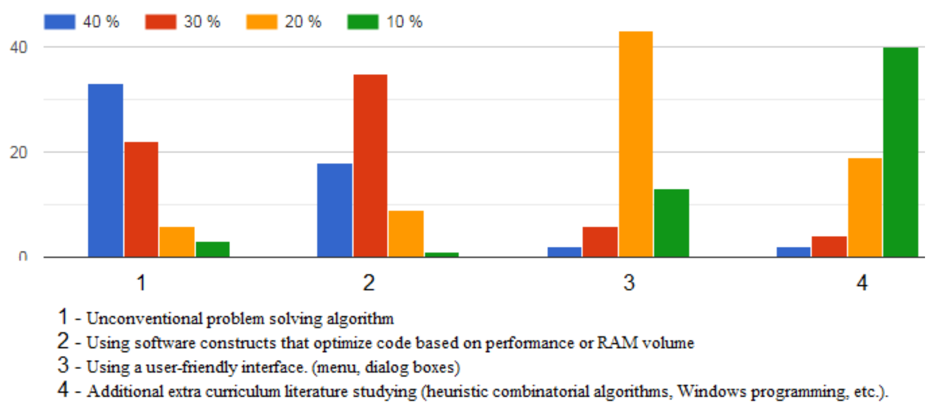

Fig. 3. Practical assignment accomplishment quality

For convenience, all these results are summarized in Tables 3, 4.

Table 3. Rating reduction percentages for practical assignments accomplishment

1. Practical assignment accomplishment		
№	Error type	% reduction
1	Syntax errors (no application compilation is running)	100
2	Logical errors leading to exceptional situations (computer "freezes")	50
3	Incorrect task realization algorithm	25
4	The result does not meet the condition of the task	15
5	Uninformative output and input of data	10
	Total	100
2. Practical tasks defence		
№	Error type	% reduction
1	The student cannot explain the practical assignment program code	50
2	The student does not answer test questions on the topic of the practical assignment	25
3	The student cannot make changes to the program to correct logical errors	15
4	The student does not know theoretical material on the practical assignment topic	10
	Total	100
3. The term of deadline non-meeting		
№	Delay period	% reduction
1	Two weeks	10
2	Two weeks to four weeks (month)	20
3	Four weeks to six weeks	35
4	Six weeks to eight weeks (two months)	50
5	Eight weeks to 12 weeks	70
6	More than 12 weeks	80

Table 4. Rating reduction percentages for practical assignments accomplishment

Practical assignment accomplishment quality		
№	Non-standard approach type	% reduction
1	Unconventional problem solving algorithm	40
2	Using software constructs that optimize code based on performance or RAM volume	30
3	Using a user-friendly interface. (menu, dialog boxes)	20
4	Additional extra curriculum literature studying (heuristic combinatorial algorithms, Windows programming, etc.).	10
	Total	100

Let us study an example of practical assignments accomplishment assessment making for a practical assignment accomplished by a student. The percentages of each decrease for practical assignments accomplishment component are summarized in Table 5. All percentages of decrease for practical assignments accomplishment obtained are summed up.

Table 5. All percentages of decrease for practical assignments accomplishment obtained are summed up.

	Rating planned	% reduction	% increase	Rating total
1. Practical task accomplishment		25		
2. Practical task accomplishment defence		0		
3. Practical task accomplishment report		10		
4. Practical task accomplishment quality			0	
5. Practical task accomplishment delay		0		
Total :		35%		
for level 6	100			65,00
for level 5	95			61,75
for level 4	85			55,25
for level 3	75			48,75
for level 2	70			45,50
for level 1	65			42,25

In other words, for example, a student chooses a practical assignment that corresponds to the sixth level, which maximum score equals 100. Supposing the student receives a 25% reduction for task implementation incorrect algorithm in the section " Practical assignment accomplishment" and - 10% for the inability to answer test questions on the topic of the practical task in the section " Practical assignment defence ". The reduction percentages are added up. The final rating points reduction depends on the total summed up reduction percentages (see Table 5). There is a possibility that the students can improve their results as well. For example, if in the “Practical task accomplishment quality” section the student received a percentage increase - the final score will be increased by the amount of that percentage.

Thus, this technique can be used to evaluate students' academic achievement using Bloom's taxonomy levels in any discipline

4 Conclusions

The present research analyzes works of Ukrainian and foreign authors on the issues of control and educational activity results assessment while working with students in higher education institutions. The principles of formative assessment and the levels of cognitive, emotional and motor goals are highlighted in the article.

Authors’ technique for educational activity results assessment for future bachelors of computer sciences, which combines Bloom's taxonomy and the classical scoring system for students' knowledge assessment and makes it possible to implement differentiated and individual approaches and build an individual trajectory of each student’s development.

The authors substantiate the content of Bloom's taxonomy levels, explain the types of activities for the assessment system on the example of designing practical tasks of the discipline "Algorithmization and programming" gives the teacher a new methodology and a new tool for assessing student achievement.

This technique, thanks to the use of Bloom's taxonomy, will enable the teachers to determine the level of competence of the student at intermediate stages of learning. Solving problems of a certain grade correctly, partially or not solving at all - the student realizes his level of knowledge.

The disadvantages include the fact that for this technique the teacher needs a large amount of time to create a set of methodological support for specialties.

References

1. Proskura, S. L., Lytvynova, S. H.: Future bachelors of computer sciences professional competency formation. Physical & Mathematical Education 2(20), Sumy, pp. 137-146. (2019).
2. Ognivchuk, L. M.: Students’ learning achievements assessment in higher educational institutions. Educational discourse № 3 (7), pp. 154-166. (2014).
3. Bocharnikova, V. M.: Stimulation function of knowledge and skills control of high school students: synopsis. dis. ... ped. sci. cand: 13.00.01, Kyiv, 23. (1999).
4. Tomilova, M.I., Vasylieva, Ye.Yu., Kharkova, O.A.: Students’ evaluation of knowledge assessment in higher education institutions. Human ecology, vol.9, pp. 29–33. (2013).
5. Borodych, S. A., Tieplyakovskaya, A. N.: Point-rating system of students knowledge assessment in higher education institutions: problems and perspectives. Innovative pedagogical technologies : mat-ls IV Internat. sci. conference. Kazan : Buk, pp. 139–141. (2016).
6. The provision on the rating system for learning outcomes assessment of NTUU "I. Sikorsky Kyiv Polytechnic Institute”. https://kpi.ua/regulations-RSO, last accessed 2020/05/21.
7. Starychenko, B. Ye. Point-rating system of students’ knowledge assessment: questions of modeling. Pedagogical education in Russia, vol. 6, pp.205-215. (2017).
8. Kukharenko, V. M.:System approach to the blended learning:Information Technologies in Education – Issue 24. Kherson, pp. 53-67. (2015).
9. Lytvynova, S.H. The model of computer modeling system use for students’ competencies formation in natural-mathematical subjects students. Physical-mathematical education: science journal. Sumy : [A. S. Makarenko SumSPU]. Vol. 1(19), pp. 108-115. (2018).
10. Proskura, S. L., Lytvynova, S. H.: Information technologies specialists training in higher education institutions of Ukraine: general state, problems and perspectives: Information Technologies in Education 35, Kherson, pp. 72-88. http://ite.kspu.edu/issue_35/p-72-88. (2018).
11. Proskura, S. L., Lytvynova, S. H.: Organization of independent studying of future bachelors in computer science within higher education institutions of Ukraine. 14th International Conference on ICT in Education, Research, and Industrial Applications (3L-Person 2018), pp. 348-358. (2018).

12. Kukharenko, V. M., Berezenska, S. M., Bugaychuk, K. L, Oliynyk, T. O., Rybalko, O. V., Theory and practice of blended learning, monograph Kharkiv: City Press, NTU KHPI, P. 284. (2016).
13. Proskura, S. L.: The model of professional competency formation for future bachelors of computer sciences. Physical & Mathematical Education 3(21), Sumy, pp. 104-112, https://fmo-journal.fizmatsspu.sumy.ua/publ/4-1-0-522. (2019).
14. Spirin O., Burov O. Models and applied tools for prediction of student ability to effective learning. 14th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. CEUR-WS, vol. 2104, pp. 404-411. (2018).
15. Mintii, I. S., Shokaliuk, S.V., Vakaliuk, T. A., Mintii, M.M., Soloviev, V.N. Import test questions into Moodle LMS. Cloud Technologies in Education : CEUR Workshop Proceedings, vol. 2433, pp. 529-540. http://ceur-ws.org/Vol-2433/paper36.pdf. (2018).