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The Taxonomy Approach for Engineering Students Outcomes Assessment

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Abstract. The paper presents the analysis of the B. Bloom's taxonomy approach to describe learning objectives in the connection with program learning outcomes as well as the assessment methodology and tools for analysis of engineering students' cognitive skills of different levels. The research was aimed at the development of some recommendations for the designing of testing items which could be realized for multilevel assessment of the results of engineering students' competency-based professional training. That was performed considering the evidences, which reflected the theory and practice of B. Bloom's taxonomy use for learning outcomes, learning activities and assessment strategy description for engineering education. The verbal means were analyzed and used for the development of the recommendations, which could be applied to formulate the learning outcomes and tasks at different cognitive levels. The application of the taxonomy approach required the development of test items provided for six cognitive categories. A set of multiple choice and open-ended tasks was developed to perform a multilevel assessment of the results of the specific course mastering by agricultural engineering students. To study how the formulation and the test item type influence the assessment results, an experiment was performed. It showed the effectiveness of differential ability of the approach when taxonomy is used for the assessment of students' learning outcomes.

Keywords: Learning Outcomes, Test, Engineering Students, Sustainability Education, Assessment, Evaluation, Validity, Test Items.

Таксономічний підхід для оцінювання результатів студентів інженерних спеціальностей

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References

1. Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H., Krathwohl, D.R.: Taxonomy of educational objectives: The classification of educational goals. Handbook I: cognitive domain. David McKay Company (1956).
2. Anderson, L.W., Krathwohl, D.: A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. Longman (2001).
3. Hernandez-de-Menendez, M., Morales-Menendez, R.: Technological innovations and practices in engineering education: a review. Int J Interact Des Manuf 13, 713–728 (2019). DOI: 10.1007/s12008-019-00550-1.
4. Felder, R.M., Brent, R.: Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. Journal of Engineering Education 92, 7−25 (2003). DOI: 10.1002/j.2168-9830.2003.tb00734.x.
5. Nagayev, V., Danchenko, I., Mitiashkina, T., Kyrepin, V.: Administrative Fundamentals of Ecological Competence Forming in Agricultural Engineering Students Under Conditions of Their Professional Training. In: Tonkonogyi, V., Ivanov, V., Trojanowska, J., Oborskyi, G., Pavlenko, I. (eds) Advanced Manufacturing Processes III. InterPartner 2021. Lecture Notes in Mechanical Engineering, pp. 697–706. Springer, Cham (2022). DOI: 10.1007/978-3-030-91327-4_67.
6. Sharunova, A., Wang, Y., Kowalski, M. et al.: Applying Bloom's taxonomy in transdisciplinary engineering design education. Int J Technol Des Educ 32, 987–999 (2022). DOI: 10.1007/s10798-020-09621-x.
7. Sharunova, A., Butt, M., Qureshi, A.J.: Transdisciplinary Design Education for Engineering Undergraduates: Mapping of Bloom's Taxonomy Cognitive Domain Across Design Stages. Procedia CIRP 70, 313−318 (2018). DOI: 10.1016/j.procir.2018.02.042.
8. Granello, D.H.: Encouraging the cognitive development of supervisees: Using Bloom's taxonomy in supervision. Counselor Education and Supervision 40(1), 31–46 (2000).

9. Firman, F., Baedhowi, B., Murtini, W.: The Effectiveness of The Scientific Approach to Improve Student Learning Outcomes. International Journal of Active Learning 3(2), 86–91 (2018).
10. Azuma, M., Coallier F., Garbajosa J.: How to apply the bloom taxonomy to software engineering. Software Technology and Engineering Practice 2003. In: Eleventh Annual International Workshop on Software Technology and Engineering Practice, pp. 117–122 (2003). DOI: 10.1109/STEP.2003.13.
11. Violante, M.G., Moos, S., Vezzetti, E.: A methodology for supporting the design of a learning outcomes-based formative assessment: the engineering drawing case study. European Journal of Engineering Education 45(2), 305–327 (2020). DOI: 10.1080/03043797.2019.1622653.
12. Verenna, A-M.A., Noble, K.A., Pearson, H.E., Miller, S.M.: Role of comprehension on performance at higher levels of Bloom's taxonomy: Findings from assessments of healthcare professional students. Anatomical Sciences Education 11(5), 433–444 (2018).
13. El-Hassan, H., Hamouda, M., El-Maaddawy, T., Maraqa, M.: Curriculum-based exit exam for assessment of student learning. European Journal of Engineering Education 46(6), 849–873 (2021). DOI: 10.1080/03043797.2021.1920892.
14. Radmehr, F., Drake, M.: Revised Bloom's taxonomy and integral calculus: unpacking the knowledge dimension. International Journal of Mathematical Education in Science and Technology 48(8), 1206–1224 (2017). DOI: 10.1080/0020739X.2017.1321796.
15. Wang, L.H.: Construction of College English Blended Teaching Model: An Outcome-Based Education Approach. Open Access Library Journal 8, 1–16. (2021). DOI: 10.4236/oalib.1107652.
16. Goel, S., Sharda, N.: What do engineers want? Examining engineering education through Bloom's taxonomy. In: Proc. of the 15th Annual Conference for the Australasian Association for Engineering Education, ED524509, pp. 1–14. Toowoomba, Queensland, Australia (2004).
17. Ferris, T.L.J., Aziz, S.M.: A Psychomotor Skills Extension to Bloom's Taxonomy of Education Objectives for Engineering Education. Exploring Innovation in Education and Research, CEER-2005, pp. 1–5 (2005).
18. Castillo-Barrera, F.E., Amador-García, M., Pérez-González, H., Martínez-Pérez, F.E.: Agile Evaluation of the Complexity of User Stories Using the Bloom's Taxonomy. In: 2017 International Conference on Computational Science and Computational Intelligence (CSCI), pp. 1047–1050 (2017). DOI: 10.1109/CSCI.2017.182
19. Bhargav, H., Akalwadi, G., Pujari N.V.: Application of blooms taxonomy in day-to-day examinations. In: 2016 IEEE 6th International Conference on Advanced Computing (IACC), pp. 825–829 (2016). DOI: 10.1109/IACC.2016.157
20. Ketchman, K., Dancz, C.L.A., Burke, R.D., Parrish, K., Landis, A.E., Bilec, M.M.: Sustainable Engineering Cognitive Outcomes: Examining Different Approaches for Curriculum Integration. Journal of Professional Issues in Engineering Education and Practice 143(3), 04017002 (2017). https://doi.org/10.1061/(ASCE)EI.1943-5541.0000324.
21. Britto, R., Usman, M.: Bloom's taxonomy in software engineering education: A systematic mapping study. In: 2015 IEEE Frontiers in Education Conference (FIE), pp. 1–8 (2015). DOI: 10.1109/FIE.2015.7344084.
22. Näsström, G.: Interpretation of standards with Bloom's revised taxonomy: a comparison of teachers and assessment experts. International Journal of Research & Method in Education 32(1), 39–51 (2009). DOI: 10.1080/17437270902749262.

23. Qamar, S.Z., Kamanathan, A., Al-Rawahi, N.Z.: Teaching product design in line with bloom's taxonomy and abet student outcomes. In: 2016 IEEE Global Engineering Education Conference (EDUCON), pp. 1017–1022 (2016). DOI: 10.1109/EDUCON.2016.7474677
24. Panchenko, A., Voloshina, A., Panchenko, I., Pashchenko V., Zasiadko A.: Influence of the Shape of Windows on the Throughput of the Planetary Hydraulic Motor's Distribution System. In: Ivanov, V., Pavlenko, I., Liaposhchenko, O., Machado, J., Edl, M. (eds) Advances in Design, Simulation and Manufacturing IV. DSMIE 2021. Lecture Notes in Mechanical Engineering, vol. 2, pp. 146–155. Springer, Cham (2021). DOI: 10.1007/978-3-030-77823-1_15.
25. Voloshina, A., Panchenko, A., Titova, O., Pashchenko V., Zasiadko A.: Experimental studies of a throughput of the distribution systems of planetary hydraulic motors. IOP Conf. Ser.: Mater. Sci. Eng. 1021, 012054 (2021). DOI: 10.1088/1757-899X/1021/1/012054.
26. Panchenko, A., Voloshina, A., Luzan, P., Panchenko I., Volkov S.: Kinematics of motion of rotors of an orbital hydraulic machine. IOP Conf. Ser.: Mater. Sci. Eng. 1021, 012045 (2021). DOI: 10.1088/1757-899X/1021/1/012045.
27. Voloshina, A., Panchenko, A., Titova, O., Panchenko I.: Changes in the dynamics of the output characteristics of mechatronic systems with planetary hydraulic motors. J. Phys.: Conf. Ser. 1741, 012045 (2021) DOI: 10.1088/1742-6596/1741/1/012045.
28. Panchenko, A., Voloshina, A., Boltianska, N., Pashchenko, V., Volkov, S.: Manufacturing Error of the Toothed Profile of Rotors for an Orbital Hydraulic Motor. In: Tonkonogyi, V., Ivanov, V., Trojanowska, J., Oborskyi, G., Pavlenko, I. (eds) Advanced Manufacturing Processes III. InterPartner 2021. Lecture Notes in Mechanical Engineering, pp. 22–32. Springer, Cham (2022). DOI: 10.1007/978-3-030-91327-4_3.
29. Gierl, M. J., Lai, H., Turner, S. R.: Using automatic item generation to create multiple-choice test items. Medical Education 46, 757–765 (2012). DOI: 10.1111/j.1365-2923.2012.04289.x.
30. Sorrel, M. A., Barrada, J. R., de la Torre, J., Abad, F.J.: Adapting cognitive diagnosis computerized adaptive testing item selection rules to traditional item response theory. PLoS ONE 15(1), e0227196 (2020). DOI: 10.1371/journal.pone.0227196.