form, reflecting the reality logically without empirical confirmation. This is a significant contribution of mathematics in natural science" [11, p. 69].

While observing the trends and development of the modern-day science [12, p. 8-12], it can be concluded that differentiation and integration are two opposite but closely interrelated processes focused on the world study and exploration.

REFERENCES

1. Kondrat'ev V.V. Fundamentalizacija professional'nogo obrazovanija specialista v tehnologicheskom universitete, [Fundamentalization of professional education in technological university], Kazan', KSTU Publ., 2000. P. 323. (In Russ.)
2. Duggan T.V., Oliver T. J. Engineering education, industry and lifelong learning, Proc. Int. UNESCO Conf. of Eng. Education (ICEE'95), May 23–25, 1995, Moscow, 1995, pp. 13–14.
3. Kondrat'ev V.V. Metodologija innovacionnogo razvitija nauki i vysshego professional'nogo obrazovanija [Methodology of innovative development of science and higher professional education], Kazan', Shkola-Publ., 2009. P. 236. (In Russ.)
4. Stear E.B. An industry role in enhancing engineering education, Proc. World Congr. of Eng. Education and Industry Leaders, July 2–5 1996, Paris: Final Report. Pt. I / UNESCO [et al], Paris, UNESCO, 1996, pp.157–162.
5. Mackney M.D.A. The engineering curricula at the United States Naval Academy, Proc. 3rd World Conf. on Eng. Education, Sept. 20–25 1992, Portsmouth, UK, Southampton, Boston, Computational Mechanics Publications, 1992, Vol. 2, pp. 27–32.
6. Prihod'ko V.M., Manujlov V.F., Lukanin V.N. Vysshee tehnicheskoe obrazovanie: mirovye tendencii razvitija, obrazovatel'nye programmy, kachestvo podgotovki specialistov, inzhenernaja pedagogika [Higher technical education: global trends of development, education programs, quality of professional training, engineering pedagogy], Moscow, MADI, 1998. P. 304. (In Russ.)
7. Anan'in A.D., Bajdenko V.I. Proektirovanie gosudarstvennyh obrazovatel'nyh standartov vysshego professional'nogo obrazovanija novogo pokolenija : metod. rekomendacii dlja ruk. UMO vuzov Ros. Federacii [Designing state education standards of higher professional education of new generation: guidelines for administrative department of Russian Universities], Moscow, Issled. centr problem kachestva podgot. Specialistov [Research center for studying quality of professional training], 2005. P. 126. (In Russ.)
8. Karpov V.V., Kathanov M.M. Invariantnaja model' intensivnoj tehnologii obuchenija pri mnogourovnevoj podgotovke v vuze [Invariant model of intensive training in multistage university education], St.Petersburg, S.Pet. Electrotechnical Inversity Publ., 1992. P.142. (In Russ.)
9. Ignat'eva N.N. Raznoobrazie putej dostizhenija celostnosti znanij u budushhih specialistov [Variety of ways to gain holistic comprehension], Integracija v pedagogike i obrazovanii [Integration in pedagogy and education], Samara, SIPK-Publ., 1994, pp. 27–32. (In Russ.)
10. Rousseau Jean-Jacques Ispoved' [Confession], Mysli o nauke [Thoughts about science] edit. by Ponomarev V. P, Kishinev, Shtiinca, 1973. P. 81. (In Russ.)
11. Vernadsky V.I. Razmyshlenija naturalista [Thoughts of a natural scientist], Prostranstvo i vremja v nezhivoj i zhivoj prirode [Space and time in inanimate and animate nature], Moscow, Nauka-Publ., 1975, Book 1. P. 69. (In Russ.)
12. Daniljuk A.Ja. Metamorfozy i perspektivy integracii v obrazovanii [Metamorphoses and prospects of integration in education], Pedagogika [Pedagogy], 1998, no. 2, pp. 8–12. (In Russ.)

UDC 74.584.31

Education Standards as a Basis for Interdisciplinary Integrative Module

Orel State University n.a. I.S. Turgenev
G.V. Bukalova

The author proves axiological function of the integrative approach, which is applied in engineering education to meet the new education standards. The conditions to enhance discipline integration process are determined in terms of systemology fundamentals. The author describes the stages of the integrative module design. The experience in the design of interdisciplinary integrative educational module (automotive transport) is shared and discussed.

Key words: integrative approach, interdisciplinary integrative module, education standards (competences), methodological perspective, professional training.

Introduction

Today, the main objective of engineering training is graduate's professional competence, which fails to be reached through summing all pieces of information obtained from different disciplines [1]. It is noteworthy that traditional engineering education is characterized by "disciplinarity", i.e. educational process comprises a range of particular disciplines, each implying certain logics of study. In this situation, it is for the student to integrate all the information, which is in contradiction with competency-based education widely implemented at higher education institutions today. Moreover, traditional "disciplinary" engineering training does not develop the ability for integrative engineering activity as well [2].

Therefore, competency-based education necessitates changes in the model of traditional engineering education. One of the pedagogical challenges is integration of studied disciplines, which implies identifying the criteria to select and structure the educational information [3].

However, traditional discrete disciplinary approach to educational process design is still important for modern engineering education, since the disciplines taught are the methodological basis for interdisciplinary integrative modules. The integrative approach to educational process design is used as a supplementary one, and the co-existence of integrative and discrete disciplinary approaches is secured by education standards, a set of education objectives, i.e. competencies [4]. These competencies are the expected learning outcomes and should be developed regardless of the approach.

Methodological basis for interdisciplinary integrative module design

The main document to regulate university educational process is basic professional education program (BPEP) designed for a particular specialty [5]. These documents prescribes the learning outcomes of university education, which are referred to as a set of competencies. As a result, each competency is obligatory to obtain, and together they are referred to as education standards. In case of discrete disciplinary training, the distribution of competencies over the disciplines is quite challengeable. This necessitates the design of interdisciplinary integrative modules, which will ensure the development of relevant competencies. The structure of such educational process is unique since it allows combining the elements which used to be isolated within the discrete disciplinary educational pattern.

G.V. Bukalova

The interdisciplinary integrative module includes:

- a list of integrated disciplines selected in accordance with the relevant criteria;
- a list of overlapping issues (topics and blocks) considered by the integrated disciplines;
- a list of laboratory and practical tasks developed in accordance with the relevant criteria.

The interdisciplinary integrative module is a product of pedagogical integration, and the performance of pedagogical product is measured in terms of its didactic consistency [3]. Integrative pedagogical products can be characterized by different types of didactic consistency:

- "updating the education elements of other disciplines while studying a particular discipline;
- combining diverse education elements of two and more disciplines (conglomerate of education elements);
- logical, associative and heuristic correlation, …combination of connatural education elements of disciplines, with keeping the elements relatively independent (didactic synthesis of new education elements);
- developing synthetic education elements from education elements of integrated disciplines, with the elements becoming strongly connected and interdependent (didactic synthesis of new education elements)" [3, p.117].

This classification can be used to define the structure of integrative pedagogical product, with due regard to the adopted level of didactic consistency.

The interdisciplinary integrative model may be considered as a system since the elements, each being easily identified, are obviously connected. Therefore, we can refer to systemology to identify the conditions for the module efficient implementation in the educational process.

In terms of systemology, the system is consistent if the bounds between the system elements are more stable than those with the environment [6]. Thus, it can be concluded that the educational objective, which induced interdisciplinary integrative module design, should only be reached by means of newly developed discipline (without involving educational tools of other disciplines, i.e. without additional bounds with the environment). This condition fulfilled, the integrative module is efficiently implemented and ensures obtaining the expected outcomes. Based on the above-mentioned systemology thesis, the bounds between the elements within the integrative module should be stable. This can be ensured through cooperation between partner educators who teach the integrated disciplines (meetings and consultations held on a regular basis).

However, the stability of bounds between the elements of the interdisciplinary integrative module should be optimal since, in compliance with another systemology thesis, the level of the element relative independence can be reduced if their interconnection is being strengthened. It is a well-known fact that engineering education fundamentals are strongly connected with autonomous scientific disciplines, which the foundation of the relevant academic disciplines rests on [7], [8]. Therefore, it is important for the integrated disciplines to remain fundamental even if the elements of the integrative model are inseparably connected.

Systemology indicates that a system acquires a new quality if it extends [6], therefore, it is possible to improve the efficiency of the integrative module implementation if to introduce additional elements of the integrated disciplines (with due regard to the element number) into the module structure. It is expected that the effect of educational activities will be more significant than that from studying the same disciplines without integrating.

Based on the systemic approach and using the integration process structure suggested by A.D. Ursul [9], the stages of interdisciplinary integrative module design can be presented as follows.

The first stage is to identify a mutual characteristic, which will become a basis for integration. In case of interdisciplinary integrative module design, this can be a prescribed competency (a set of competencies) or a particular requirement of the professional education standard [10], [11]. The basis for integration is a core factor of the integration process development and the choice of the basis is crucial for pedagogical integration efficiency.

The next stage is to identify the systems to be integrated. In our case, it is necessary to identify the academic disciplines, which serves as the basis for integration.

After that, one should determine the area of integration. Based on logical, associative and heuristic assumptions, a set of education elements to be integrated is determined. The integrated elements, which together make the area of integration, are certain blocks within academic disciplines, laboratory works, project work tasks, and self-study resources.

Then the education elements within the area of integration should be ordered in terms of their significance. The criterion for ordering is the element's role in the development of a particular competency or contribution it makes to meet a particular requirement of the professional education standard (taken as a basis for integration) – the element impact can be objective, methodological, or categorical.

The product of pedagogical integration is officially implemented as an interdisciplinary integrative module (study pack developed from the materials of integrated disciplines).

Integrative approach implementation

The workgroup of Orel State University n.a. I.S. Turgenev conducted a survey among the employers who run the most successful vehicle service stations in Orel. The respondents were the heads of the following companies: OOO "Vozrozhdenie" (authorized dealer of Ford, Renault, Volkswagen, Nissan, Hyundai, Mitsubishi), OOO "Forpost – Orel" (authorized dealer of KIA), ZAO "Orelavtotekhobsluzhivanie"; automotive holding company "Atlant M – Auto" (authorized dealer of Chevrolet, Opel, GM-AvtoVAZ). The staff policy at the enterprises is conducted in cooperation with the Department of Machine Service and Maintenance, Orel State University. The questionnaire for the survey was developed to find out whether the professional education standards (relevant competencies) of "Operation of Cars and Transport Systems" program meet the requirements of the employers. The survey results indicated that the employers are rather interested in student training for innovative activities in automotive service sector. The competencies mentioned in the questionnaire and reflecting graduate's ability to perform innovative activities were estimated by the employers as "very important" and "the most important".

To train students for performing innovative activities in automotive service sector, the methodology for interdisciplinary integrative module design has been developed. According to the classification describing different types of didactic consistency of an integrated pedagogical product, the developed interdisciplinary integrative module is based on logical, associative and heuristic combination of connatural education elements of disciplines, with keeping the elements relatively independent.

The basis for integration, a core factor of the integration process development, is graduate's competency, namely, the ability to perform innovative professional activities.

The criterion to identify the systems (i.e. academic disciplines) to be integrated is the general stages of innovation implementation: need for innovations, fundamental research, applied research, use of innovation, positioning on the market [12].

The area of integration was determined through selecting the education elements of the integrated disciplines: lectures, laboratory works, project work tasks, and elements of graduate qualification work.

The area of integration includes not only the education elements which improve student's ability for performing innovative activities in automotive service sector, but also the elements which encourage innovative thinking.

Based on the expert analysis, the education elements were ranged as "significant", "very important, "the most important".

Conclusion

Interdisciplinary integrative module implementation stipulates integrative training sessions: polydisciplinary lectures, interdisciplinary engineering project activities, integrative self-study tasks.

Compared to traditional educational process, the integrative one is characterized by detailed structure and allows developing an integrative way of thinking, which can be considered a supplementary target. In fact, it is the integrative way of thinking that lays the foundation for successful engineering activities in any manufacturing profile.

SPECIALISTS' TRAINING FOR INTERDISCIPLINARY TEAMWORK AND PROJECTS

REFERENCES

1. Zimnyaya I.A. Klyuchevye kompetentnosti kak rezul'tativno-tselevaya osnova kompetentnostnogo podkhoda v obrazovanii [Key competencies as a basis for competency-based approach in education]. Moscow: Issledovatel'skii tsentr problem kachestva podgotovki spetsialistov, 2004. 42 p.
2. Verbitskii A.A., Larionova O.G. Lichnostnyi i kompetentnostnyi podkhody v obrazovanii: problemy integratsii [Personality-oriented and competency-based approaches in education: integration challenges]. Moscow: Logos, 2009. 336 p.
3. Semin Yu.N. Integratsiya soderzhaniya inzhenernogo obrazovaniya: didakticheskii aspect [Integration of engineering education content: didactic perspective]. Izhevsk: Publ. IzhGTU, 2000. 140 p.
4. Bukalova G.V. Kontseptual'nye osnovaniya normirovaniya rezul'tata professional'nogo rezul'tata tekhnicheskogo profilya [Standards for engineering education outcomes: conceptual framework]. Orel: Gosuniversitet – UNPK, 2014. 421 p.
5. Metodicheskie rekomendatsii po razrabotke osnovnykh professional'nykh obrazovatel'nykh programm i dopolnitel'nykh professional'nykh programm s uchetom sootvetstvuyushchikh professional'nykh standartov, utverzhdennye Ministrom obrazovaniya Rossiiskoi Federatsii Livanovym D. V. ot 22.01.2015 □ DL-01/05vn. [Elektronnyi resurs] [Recommended practice for basic and additional professional education program design with regard to professional standards; approved by the Minister of Education of the RF D.V. Livanov, dated January 22, 2015, № DL-01/05 vn.]. FGOS VO: portal [FSES for Higher Education: official website], 2016. URL: http://fgosvo.ru/uploadfiles/metod/DL1_05_2015 (Accessed: 27.05.16).
6. Surmin Yu.P. Teoriya sistem i sistemnyi analiz [System theory and analysis]. Kiev: MAUP, 2003. 368 p.
7. Nikitaev V.M. Inzhenernoe myshlenie i inzhenernoe znanie (logiko-metodologicheskii analiz) [Engineering thinking and engineering knowledge: logical and methodological analysis]. In Rosov M.A. (ed.) Filosofskie nauki [Philosophical sciences]. Msocow: Russian Academy of Sciences, Institute of Philosophy, 1997. Vypusk 3: Problemy analiza znaniya [Issue 3: Challenges of knowledge analysis], pp. 152–169.
8. Chuchalin A.I. Modernization of Engineering Education Based on International CDIO Standards. Engineering Education, 2014, no. 16, pp. 14–29.
9. Ursul A.D. Filosofiya i integrativno-obshchenauchnye protsessy [Philosophy and integrative process in science]. Moscow: Nauka, 1981. 367 p.
10. Metodicheskie rekomendatsii po aktualizatsii deistvuyushchikh federal'nykh gosudarstvennykh obrazovatel'nykh standartov vysshego obrazovaniya s uchetom prinimaemykh professional'nykh standartov, utverzhdennye Ministrom obrazovaniya i nauki Rossiiskoi Federatsii Livanovym D. V. ot 22. 01.2015 № DL-02/05vn. [Elektronnyi resurs] [Recommended practice for updating federal state educational standards for higher education with regard to professional standards; approved by the Minister of Education of the RF D.V. Livanov, dated January 22, 2015, № DL-02/05 vn.]. FGOS VO: portal [FSES for Higher Education: official website], 2016. URL: http://fgosvo.ru/uploadfiles/metod/DL2_05_2015.pdf, (Accessed: 27.05.16).
11. Blinov V.I. et al. Professional'nye standarty: ot razrabotki k primeneniyu [Professional standards: from development to implementation]. Vysshee obrazovanie v Rossii [Higher Education in Russia], 2015, no. 4, pp. 5–14.
12. Lapin N.I. Teoriya i praktika innovatiki [Innovation studies: theory and practice]. Moscow: Universitetskaya kniga, Logos, 2008. 320 p.

ENGINEERING EDUCATION
20'2016