Research Article

Eliminating curricula deficiencies for Informatics teacher specialty in Azerbaijan

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Abstract. The article investigates higher education curriculum shortcomings and their impact on the development of school teaching of informatics in Azerbaijan as well as underlines the role of timely taught informatics for the economy of the country and students' well-being. The article summarizes the steps taken in the field of informatics curriculum improvement. Moreover, it offers arguments against the efficiency of the current education system and suggests solutions which may help overcome the existing deficiencies. Curricula of the Ganja State University and the Azerbaijan State Pedagogical University, which prepare students on the specialty of Informatics Teacher, were compared based on the results of document review. The shortcomings of both curricula were identified and classified, examples of deficiencies and ways to remedy them were proposed. The principles of continuity and sequencing of curriculum during school and first two years of university studies were emphasized. The study involves the causal relationships between the new steps made in the domain of curriculum design on different stages of education in Azerbaijan and the deficiencies which arise in informatics education despite the fact that successful innovations, new subjects, programs, textbooks, trainings, approaches and principles are being discussed, explained and compared to those emerging in the world educational process.

Keywords: Subject curricula, programs, teaching staff, competencies, informatics.

1. Introduction

Perfecting education in higher education institutions needs altering curricula first. Although a long time has passed from the master's level of higher education, changes in curriculum and succession issues have not been resolved yet. Its improvement is influenced by a range of factors: presence (as in the UK) or absence (as in Germany) of a national curriculum, its content, number of teachers available (their abundance or shortage) as well as support provided to them aimed to ameliorate their teaching skills (Maass et al., 2019).

The whole educational process is build designed around curriculum. It facilitates achieving the goals which education and training set, which are mostly dynamic in their nature and change alongside with socio-economic requirements. Thus, the curricula are capable of adjusting according to the newest trends in education and training, and change to develop skills relevant to labour market, As Cedefop's report on work on skill mismatch claims, although increasingly more people are acquiring education, about a third of European companies note that their employees lack necessary skills. Therefore in the research paper Cedefop investigates benefits of implementing outcome-oriented system of training as being the most beneficial one for both trainees and vocational market (Cedefop, 2012). Curriculum and subject content have not been changed in most Azerbaijan schools. One of the main reasons for this is the lack of preparation for the transition to both systems, the introduction of the system through hasty decisions. This work should be carried out in stages, not in a short time. Although much time is not required to eliminate this deficit on humanitarian subjects, in technical disciplines, this is more apparent.

Proper informatics education is extremely rare in most European countries and, paradoxically, the situation has pejorated since the 70s–80s of the last century. ACM Europe and Informatics Europe's main concern is that European nation may cause harm to their primary and secondary school students not only in educational, but also in economical respect. If a proper curricula and informatics education is not established, it can jeopardize European economics and hinder development of the students compared to those of other countries (India being the most apparent example). In order to eliminate this problem it is crucial that an informatics curriculum is based on two major principles agreed upon by informatics curriculum experts. According to those, it is required that school informatics curriculum stimulates students' creativity and emphasizes quality (Informatics Europe, 2013).

The K-12 Computer Science report (Tucker, 2003) notes that in the USA there is no "deliverable" curriculum for computer science education, but what is highlighted is that "teachers must play a substantial and leading role in the formulation of curriculum components", which cannot be performed without university faculty and professional organizations' (such as ACM and ISTE) assistance.

The subjects “Mathematics” and “Technology”, which are rooted into elementary school, teach certain aspects of Informatics and each elementary school is allowed to imbed the subject of Informatics into its curriculum. That enables designing various Informatics courses and creating numerous teaching materials. However, textbooks for school use must comply to Federal Education Standards requirements and be certified (Khenner & Semakin, 2014).

Teaching of informatics in elementary school is of exceptional importance since gaining basic computer skills by the age of 12 is advisable as it will allow to deepen the students’ knowledge in the secondary school and prepare graduates who are fluent in digital technologies (Informatics Europe, 2013).

Despite the involvement of innovative techniques into teaching of such disciplines as informatics and mathematics being addressed as a way to evoke students’ interest in the subjects and improve their understanding thereof (Vlasenko, 2019), introduction of those may pose certain difficulties. The gap between how policy makers view the process of education, how education researchers design the curricula and how schools implement them can differ drastically and, therefore, “the learning goals on which teaching approaches to focus are frequently at odds with national assessment that prioritize procedural competences at the expense of conceptual understanding, procedural fluency, problem solving, and mathematical communication” (Maass et al., 2019).

Ministry of Education of Azerbaijan has been following the world-wide tendency of computerization as a step towards reflecting modern standards of informatics education. A program of improving informatics education included, firstly, supplying schools with a sufficient amount of technical equipment and creating a virtual environment for teachers and pupils. Then the number of electronic libraries and opportunities for distant education was to be expanded. Thus, achieving the flexibility as the main positive aspect of distant education (Ukhov et al., 2020). As teachers are crucial in implementation of all the innovations and improvements, a new mechanism of their recruitment was to be perfected, more teachers were to be encouraged to work in remote villages and a result-based system of rewarding as well as differential salaries were to be introduced (Samadova, 2016).

Informatics as a school curriculum subject appeared in the USSR in 1985, the same year regular teachers training began. Originally students were qualified as “Teacher of Informatics” after completing a 5-year course. Nowadays, there are mostly two levels of training. First level of education is achieved through 4-year long Bachelor’s program (Informatics is a sole specialization) or 5-year long Bachelor’s program (dual specialization, for example “Mathematics and Informatics”) (Khenner & Semakin, 2014).

Computer science curricula include the following elements, which are arranged in the curriculum according to the qualification of the students: programming and programming languages, design (hardware and software design), networks, graphics, databases, cybersecurity, logic, programming paradigms, translation between levels of abstraction, artificial intelligence, the limits of computation, applications in information technology and information systems, and social issues (privacy, intellectual property, etc.) (Tucker, 2003).

New steps in Azerbaijan school and university curricula as for the end of 2019 year

1) The textbooks of elementary and secondary Azerbaijan schools have been updated with regard to nationalization processes and according to a preparation to a new Bologna system in high schools. Earlier only the specialists approved by the government as being loyal to it were authorized to prepare school and university textbooks. Textbooks were mostly compiled by PhDs and professors working at the Academy of Sciences at Baku State University and Pedagogical University (Rumyansev, 2019). But as for the end of 2019 year, alternative textbooks appeared.
2) In July 2019, the preparation of a new, reserve format for textbooks on a number of subjects in the elementary grades — mother tongue, mathematics, and a foreign language — began. These textbooks are already being tested in 100 schools of Azerbaijan (Sultanova, 2019).
3) More teachers were recruited to Azerbaijanian secondary educational institutions and vocational lyceums. 2014-2015 academic year 1692 persons received jobs and 1405 persons (83%) were applied motivation actions. The level of filling vacancies reached 40% (Ministry of Education Republic of Azerbaijan, 2015).
4) The 31st International Olympiad in Informatics took place in Baku in August 2019. Official delegations equaled to more than 600 pupils, teachers and experts who had come from 88 countries and regions in total. Theeams which had represented Azerbaijan in the Olympiad 24 times had won 5 medals. The International Olympiad in Informatics is one of the most prestigious contests held annually. It offers students from many around the world a chance to measure and demonstrate their knowledge (Ministry of Education Republic of Azerbaijan, 2019).
5) In February 2019 UNICEF collaborated with the Ministry of Education to organize a training for 28 pedagogical university teachers and a group of 50 in-service teachers in Baku. Having passed the training the

teachers could train further 300 university teachers, more than 1,300 students of pedagogical universities (5 in total) and over 10,000 = teachers from primary schools in Baku, Sumgayit, Agjabedi, Guba, Ganja, Sheki and Gazakh during 2019-2020 (UNICEF Azerbaijan, 2019).

6) In the 2019-2020 school year, 42 schools in Baku and Absheron began to teach information and communication technologies for sixth grade students as a part of a pilot project. The new subject of STEAM covered six thousand students. The difference between the STEAM subject and the familiar "Informatics" subject is that children do not just learn a programming language, they are taught design programs. Teachers help students assemble robots, program them, develop their own design ideas, print mock-ups on 3D printers, activate objects not only on computer monitors, but also make robots assembled manually (Orudzhalieva, 2019). Such an innovation demands extending teachers' skills.

7) In the period from 2005 to 2014 higher education institutions in Azerbaijansuffered from slow implementation of a United Nations Decade of Education for Sustainable Development. The implementation was hindered due to such obstacles as poor awareness and expertise of the employees, inappropriate curricula and conservative materials and teaching methods (Biasutti, 2016).

8) Conducting entrance exams through testing since 1992 has been harming teaching of exact sciences, working in secondary schools with the new curriculum principles and the massive transfer of universities to the Bologna system have deepened the gap between these two levels.

9) Allocation of higher education to bachelor and master degrees resulted in the changes of curriculum. High school teachers who did not clearly understand what was happening were unable to define accurately and correctly the magistracy disciplines. First of all, this happened with the slight changes of the subjects taught at the bachelor degree, and subsequently resulted in the selection of subjects that were irrelevant, unscientific. Most of these disciplines were subjects with less importance for the specialty.

In subsequent years there was not enough interest and conditions in updating school and university curricula in Azerbaijan. More skilled professionals and material base are needed for realization of this work. However, in many foreign countries, specialists are engaged in this work and they are financially funded individually for this work. The design process of a new curriculum, according to the KÖNDEM curriculum evaluation model is to embrace the whole designing process, stages of implementation, assessment and development (Yazçayır & Selvi, 2020). When Informatics content is integrated into the curriculum, the outcomes of it should be clear. Moreover, Informatics can be taught as a stand-alone course, in this case it would be reasonable to divide its content into manageable portions to clarify the main concepts.

2. Method

In this study the curriculum of higher education institutions in Computer Science, Mathematics and Informatics, as well as the curriculum of Informatics Teacher specialties, is considered. A comparative analysis of the curriculum of Ganja State University (GSU) and Azerbaijan State Pedagogical University (ASPU), which have student quota on the specialty of Informatics Teacher, is held based on the document review. The resources of data and tools included: the curricula themselves, observation, SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, beneficiary opinions, analyses of the existing curricula and a draft of the new, analyses of the draft curricula (both previous and existing) according to beneficiary opinions compared in all curriculum dimensions (their context, aim, content, processes of learning and teaching as well as measurement and evaluation).

Permissions to obtain university curricula were received beforehand. The curricula were then analyzed according to the SWOT Analysis principles in order to reveal strengths and weaknesses of those as well as to discover opportunities for their improvement and threats which university curricula can face. The main advantage of the SWOT Analysis is that it leads to using the features ingrained in the system to its benefit (Madsen, 2016).

To assess the curricula the KÖNDEM model was employed. The model is two-dimensional and involves desk-based curriculum analysis and beneficiary analysis. KÖNDEM evaluation can be applied for analysis of both existing and drafted curricula (Yazçayır & Selvi, 2020).

3. Results

Comparison of the mentioned two curricula showed that they are identical or have been transferred from one another. The difference is only in terms of total hours and corresponding credits. The subjects given in the curriculum of all three specialties are 90 percent identical. It is proven that the subjects of 1st block of all three curricula are the same, but it is not completely similar to the subjects of the 2nd block (vocational training) — it is about 90 percent. The GSU curriculum has fewer hours and loans than ASPU. There is also a difference in the number of subjects, 39 in GSU and 40 in ASPU. The number and alternation of subjects offered on the selected subject blocks still constitute majority in ASPU.

Shortcomings (deficiencies) features of the curriculum

1. The incompatibility of the number of hours specified in the curriculum with the real time division given to it.
2. Placement of disciplines that are of no importance for the specialty subject in the curriculum.
3. Incorrect selection of teaching subjects time and the lack of interdisciplinary relationship and succession.
4. Failure of determination of semester teaching load in the growing order and in accordance with the students' activities, etc.
5. Absence of system in the subjects of the specialty-vocational training section.

Deficiencies arguments in accordance with our classification and their solutions

The first argument

The amount of time devoted to studying the subject does not correspond to weekdays available in the semester. During this semester the study of the theoretical material was given 15 weeks. During this period, state-level holidays are observed every year. Therefore, at the end of the semester, there is a need for additional hours for the completeness of the program. Adding one or two hours per subject at the time when the semester is ending overloads students and teachers. Considering the final evaluation of colloquiums and free work, it is easy to imagine that the difficulty is bigger. This has a very negative impact on quality.

Solution:

In some subjects, both the lecture and the practical lessons are determined by one hour, which means that the last lesson is unfinished. Imagine that in a merger the lesson ends after 40-45 minutes, students go to the break and this time a lesson is conducted in other neighboring audiences. This also leads to the violation of the lessons. For example, 45 hours are reserved for each lecture and laboratory studies on the subject “Operating System and Computer Architecture”. One should be increased, and the other one should be reduced. Concerning the content of the subject, some of the topics need to be taught as a theoretical material, as a seminar and others need to be taught as laboratory studies. For example, it would be better to teach 30 hours of lectures, 30 hours of workshops, and 30 hours of laboratory studies.

The second argument

This argument is more clearly reflected in the curriculum. For example, in the humanitarian subject block, 150 hours have been devoted to the teaching of the subject “Azerbaijani language and Speech parts”, which is a subject of secondary importance for the Informatics teacher specialty. 90 hours of these total hours are intended for out of audience and 60 hours are for audience (30 lectures and 30 seminars). Since the beginning of teaching with our national curriculum in secondary schools, the Algebra and the Beginning of the Analysis is not taught in the X-XI grades. In these classes, as well as other classes, topics related to 5 content lines and appropriate standards are implemented.

In previous textbooks, issues of proof were given broadly relating to the Algebra and Beginning of the Analysis. Conducting of entrance exams by tests has completely weakened the tendency towards this area. Students who are admitted to the high school with high scores cannot fulfill the theoretical and practical assignments related to proof. Students do not understand the lectures on mathematical analysis which were passed 20-30 years ago; they lose interest in teaching material and in science. After all, previous status of graduates of the same program also covered the level of master's degree. These graduates had the opportunity to be admitted directly to the doctorate, at present it is not necessary. That's why students see themselves among people who cannot achieve success in this area.

Solution:

In order to eliminate this shortage, it is proposed that in the first semester of the I course "Some Issues of Algebra and Mathematical Analysis" will be taught instead of "Mathematical analysis". The materials which are not taught directly at secondary school but are important for the study of Mathematical Analysis must be included in the content of the subject. This can be attributed to the teaching of the subject of Algebra and Geometry.

It is intended to teach the Ordinary Differential Equations subject in the first semester of the II course. The chances of a student, who is still unable to master mathematical analysis, to learn this subject are small. This subject does not need to be taught in the specialty of Informatics, or it is expedient to teach a few simple materials related to secondary school. This can be applied to the subject of Probability Theory and Mathematical Statistics.

The most unacceptable fact is that, such subjects as, Mathematical Physics Equations, Theory of Real Variable Functions, Functional Analysis and Theory of Complex Variable Functions are included in the curriculum on this specialty in a selected subject block. Even some of them begin to be taught in the II course, whereas, according to the principle of continuity, students will not be able to comprehend the content of the subject. However, there is a need for new disciplines and programs related to Informatics instead of these subjects.

The third argument

This argument includes some subjects in the curriculum without taking into consideration the continuity. The subject of Algorithms Theory can be shown as an example. As for the content of the subject, there is a considerable amount of material about higher mathematics. According to the curriculum, the subject must be taught in the I course, but during this time the students' knowledge in higher mathematics is insufficient. On the contrary, Operating Systems and Computer Architecture subjects are taught in the III course, although they should be taught in the I course.

Solution:

Operating Systems and Computer Architecture subjects are not dependent on other subjects; therefore, there is no need to wait for the succession here. Usually, due to inexperience, most of the students from the first course may have an academic debt. In the absence of continuity, they may be admitted to other subject disciplines in the next semester. Transferring them will allow the students to give their credit debt later. In the next semester this creates even greater challenges for subjects with succession. In the fourth grade a student has 5-6, sometimes even more credit debts. Such situations create new problems both for students and parents, as well as for the university. Such examples are present in the Ganja State University and Azerbaijan State Pedagogical University curricula.

The fourth argument

This argument is reflected in non-compliance with the principle from easy to difficult, from simple to complex in the curriculum in accordance with the growing strength of the students and their psychological preparation. The number of subjects taught in the first semester of the I course was equal to 6, and equal to 5 in the 2nd and 3rd semesters.

Solution:

In the first semester it should be less, in the subsequent semesters — the number of subjects could be higher.

The fifth argument

Subjects of the specialty-vocational training section was incorrectly arranged at the time when the content of the disciplines was still not clear enough and the literature was insufficient, and today it remains the same. The subject of Application Programs has been included in the sixth block; the subject of MS Access database has been included in the seventh block.

Solution:

In fact, the subject of Application Programs should be included in the MS Access database, or to be one of the more specific application programs in the previous block.

4. Discussion and conclusions

From the given results and their discussion, it can be concluded that it is impossible to educate teachers with the required competencies (Ivanov, 2007; Hainovskaya, 2009; Vlasenko et al., 2019) with existing curricula and subject programs. Informatics content can be introduced into the curriculum as an independent course with its content divided into manageable portions easier to comprehend and providing information about the major concepts of informatics (Vottero, 2017).

The findings of the research agree with the ones of the previous studies on the subject of curriculum deficiencies elimination. It has been revealed that curricula in two studied universities would benefit of postponing certain subjects to a later course (Vlasenko et al., 2019), nevertheless, the continuity of the curriculum must be preserved (Educational research techniques blog, 2014). Although there is a consent between the researchers on the subject that teachers' role in implementing all the curriculum innovations is impossible to overestimate (Clark-Wilson & Hoyles, 2019; Maass et al., 2019; UNICEF Azerbaijan, 2019) such a deficiency as non-compliance of time devoted to a subject and weekdays available in the semester had often been missed in previous studies.

One usually resorts to innovative teaching approaches in the context of inplementing a new curriculum, a teacher training, a professional development program, or a combination of these two (Maass et al., 2019). The Cornerstone Maths project which started in England in 2011 can serve as an example as it began with designing some curriculum units that combined digital technology and mathematics learning, and therefore was called dynamic mathematical technology (Clark-Wilson & Hoyles, 2019). The works of many scientists also agree that the computer and information technology positively imfluence students' motivation (Vlasenko et al., 2019).

And for improving continuity of university education, new metrics was suggested to evaluate student ongoing learning. Jirgensons and Kapenieks (Jirgensons & Kapenieks, 2018) offered blockchain technology to be vastly adopted by educational institutions. Each block is identified with a signed and dated hashtag. As information enters the blockchain, it can neither be changed nor removed. Any correction appears near the original entry. If a correction is entered, it appears next to the original entry. Universities can boast some advantages in this respect: it would cut costs and benefit security, but also it could store students' credentials. Moreover, with the help of blockchain technology the growing demand for permanent and verified documentation could be satisfied.

Darling-Hammond et al. noted that interdisciplinary teaming is of great importance for teachers (Darling-Hammond et al., 2019). Using this structure enables teachers to exchange their knowledge in the field of planning curriculum to meet students' needs and make the curriculum more cohesive, thus supporting students emotionally and cognitively. Changes curricula would place more emphasis on developing students' communicative and collaborative skills, which are left without proper attention by current school curricula (Li et al., 2019). Using this idea as a starting point science, technology, engineering, and mathematics (STEM) education promotes students' participation in group activities which involve meaningful instruction, modeling, and provides feedback on their collaborations. Collaborative classroms provide students with a chance to learn from one another while actively engaging and internalizing academic language and practicing mathematical discourse (McGraw-Hill, 2017).

The principles of continuity and sequencing of curriculum in the third and fifth arguments are supported by the strategies of elaboration learning when the knowledge acquired most recently is ascribed a meaning through the previously learned knowledge (Aslan & Aktaş, 2020). Continuity means repetition of major concepts within the curriculum whether it is vertically or over time. Repetition and expansion are main for this strategy. A teacher presents an idea and later returns to it to cover it with another layer of complexity, repeating it until the concept is fully explained to the students. Jerome Bruner is famous for developing the spiral curriculum, which means that ideas are developed and redeveloped during the entire course of a curriculum. It was he who first documented and explained this technique. Prerequisite learning is a kind of sequencing which implies that advanced knowledge must be preceded by some less complex knowledge. Unlike in simple-to-complex which it reminds of, the sequence in which prerequisite knowledge is taught is insignificant as long as it is fully addressed before advancing to the more complicated knowledge. Many college majors must have prerequisites taken prior to other classes (Educational research techniques blog, 2014).

Curriculum, teaching a subject, assessment and learning environments should all place emphasize on learning outcomes, and those transversal competences which necessitate employing innovative and crosscurricular methods should be adressed particularly (Cedefop, 2012). Teaching quality or teaching outcomes are harder to measure. While teaching volume can be measured by analyzing the number of courses taught, it is impossible to assess teaching impact even with student evaluations (Jonker & Hicks, 2014). The strategic framework on European cooperation in education and training (ET 2020) and the Bruges communiqué drew special attention to the fact that modernizing vocational education and training can be significantly furthered by curriculum reform and curriculum renewal so that it may respond to learners' employment and personal needs better.

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