

Addressing Linguistic and Cultural Heterogeneity in Chemistry Classrooms: Findings from the In-Service Teacher Training Program

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Abstract: One of the challenges in the teaching science in Bosnia and Herzegovina is its plurality of languages and cultural diversity. In the previous initial teacher education, there was a lack of quality preparation for these modern challenges; opportunities to teach cultural and linguistic diversity were not recognized. Therefore, the challenge is to encourage experienced chemistry teachers to develop competencies for an intercultural teaching environment within the Educating Science Teachers for All (ESTA) project. The participants of the in-service professional development program were chemistry teachers from three cantons in Federation of Bosnia and Herzegovina. The aim of the program was to develop and improve professional competencies through workshops and work in groups, with discussions on selected topics and laboratory exercises with the use of modern laboratory equipment and ICT. Teaching opportunities were offered in linguistically diverse classes, as well as in classes with other forms of student diversity. The results showed that teachers are aware of the need to be sensitized for student differences. They expressed positive impressions and willingness to adjust the teaching material according to the needs of their students, but also the need for further support through collaboration with the university staff.

INTRODUCTION

Bosnia and Herzegovina (BiH) is a country with a long and rich history, which is reflected in its cities, monuments, symbols, artifacts, and rare books. BiH is home to three constituent nations and 17 national minorities, which reflect cultural diversity and an invaluable contribution to BiH society. The development of national identity is based on the understanding of nationality in BiH, most often caused by the narratives of certain ethnic groups.

There are several educational systems in BiH that exist side by side. At the level of primary and secondary education, students are often separated according to the religious and cultural group they belong to.

According to the recent population census (2013), more than 96% of residents belong to one of three main ethnic groups: Bosniaks (predominantly Muslims), Serbs (predominantly Orthodox Christians), and Croats (predominantly Catholic Christians).

They all live in the same country, but learn different interpretations of historical events, have different religious education, and are taught in different languages, which they speak now.

However, these main ethnic groups in BiH share a significant part of the ancient gene pool that is unique to the Balkan region (Marjanovic, Fornarino, Montagna, et al., 2005).

Linguistic heterogeneity

The disintegration of the common Serbo-Croatian or Croato-Serbian language (official language in SFR Yugoslavia) happened in the 1990s, along with the disintegration of the state. For linguists, this was not unexpected because the preconditions existed long before. The Serbo-Croatian language has always had two variants (Eastern/Belgrade, and Western/Zagreb), as well as two expressions (Bosnian and Montenegrin), which had their own special linguistic upgrades according to different linguistic heritage, cultural and traditional peculiarities.

The disintegration of the common state only accelerated the process of creating independent national languages.

Today, there are three standard languages in official use in BiH: Bosnian, Croatian, and Serbian (all three in Ijekavian pronunciation), and two alphabets (Latin and Cyrillic). Teaching in BiH is conducted in the official languages.

However, teachers encounter difficulties when they have to plan and realize the teaching process in practice for each student in his/her native language, which is guaranteed by the Constitution of Bosnia and Herzegovina (1995). It was quite simple in “mono-national” environments where classes are conducted in the language of the majority of students, but problems have arisen in multinational environments and have not been fully resolved. Most of the solutions so far have not been recognizing and nurturing linguistic heterogeneity. For example, in FBiH there are “two schools under one roof” – a model where the teaching process is performed in one building but in two different languages. Students are segregated based on their ethnicity and therefore seriously discriminated (Ibrahimović, 2015). Last, but not least, there are schools whose students speak languages different from the official languages of Bosnia and Herzegovina (English, French, Turkish, etc.).

The importance of language for learning chemistry

Language plays various and difficult roles in the teaching and learning chemistry, especially given the changing character and diversity of the student population in terms of aptitude, language, and culture. The relevance of communication as the ability is demonstrated by numerous activities that take place in the classroom, such as reading, writing, listening, and speaking. All these activities require different aspects of language use (Markic, Childs, 2016).

It is worth mentioning that for teaching the language of chemistry, teachers use the language spoken in the country where they work. The scientific language of chemistry (chemish) is essential for communication and understanding of chemistry, but it is also one of the major difficulties in teaching and learning chemistry in a school context (Mönch and Markic, 2022). Regardless of the students' native language, the principles of chemistry language (nomenclature, formulae etc.) are common to all students (Markic, Childs, 2016) and follow the universal guidelines prescribed by IUPAC (International Union of Pure and Applied Chemistry).

Group work in context of linguistic and cultural diversity
Group work is a superior technique for conceptual learning, creative problem solving, and academic linguistic skills development, but it also improves intergroup relations by increasing trust and friendliness. It increases and deepens opportunities to learn content and develop language and thus has the potential to build equitable classrooms (Cohen and Lotan, 2014).

Teacher-centered approaches result in considerably less active practice than a group activity, where students talk and share knowledge and ideas. Language acquisition experts agree that children learn language in a more casual, meaningful setting (Cohen and Lotan, 2014).

Multimedia learning

Extensive research has shown many positive effects of multimedia-based learning. It combines interactive media with text, static and dynamic images or videos in a teaching subject matter (Nazir, Rizvi, Pujeri, 2012). It enables teachers to deliver more innovative materials and motivate students to learn, as they have proven to be more effective than the teacher's lecture material itself (Nazir *et al.*, 2012, Osamah, Fong, Ziad, 2010).

Since the necessary measurement devices for chemistry and science education are often too expensive, and sometimes difficult to use and outdated, quantitative measurements has long been a challenge in chemistry teaching (Wejner and Wilke, 2022). Instruments such as conductometers, pH-meters etc. are usually intended for professional use, which has specific requirements regarding reliability, accuracy, and compatibility with some other equipment or software. Their distribution is performed through limited and specialized channels. It is not easy for an interested teacher to purchase them (Koželj and Istenič, 2013).

However, there are various possibilities for implementing group work and integrating ICT in chemistry classrooms. In order to increase the effectiveness and meaningful adoption of ICT in schools, it is important to look at the perspectives and practices of instructors. International suppliers (e.g. Phywe, Vernier, Pasco) offer devices at acceptable prices, optimized for educational purposes. The device requires a mobile phone or tablet with a free measuring application installed. Moreover, collections of experiments are freely available on the Internet as a valuable resource for teachers.

There is evidence from certain national and international research that using tablets in chemistry lectures improves students' motivation, attention, and independence (Wu, Lee, Chang, *et al.*, 2013). For instance, Augmented Reality (AR) technology enables the viewer to simultaneously examine real and virtual content, using appropriate applications. This technology is increasingly interesting for education purposes due to its free accessibility and widespread availability on mobile devices. It provides the opportunity to design personalized, interactive learning environments (Huwer and Seibert, 2018). Moreover, some studies (e.g. Gallardo-Williams and Dunnagan, 2021) showed that creating learning material without students' input minimizes teachers' bias regarding students' races, gender identities, and ethnicities, as well as their talent. Some students might find it difficult to work with an instructor in a personal setting, so this approach can offer them the opportunity for personalized learning environment.

The ability to visualize events that cannot be observed, such as the submicroscopic level of representation, makes it particularly useful for chemistry instruction. The learning process can be supported by the simultaneous presence of the real environment (chemical experiment) and the virtual content (visualized description of chemical processes (Thyssen, 2017, Aufenanger, 2017).

Intercultural education

One of the major challenges for science education in Bosnia and Herzegovina is the pluralism of languages and cultures in the country. Therefore, teachers should understand and apply the main parameters of intercultural education.

Intercultural education promotes values, empathy, openness, coexistence, assertiveness, curiosity, readiness for change, and respect for and preservation of cultural heritage (Bartulović and Kušević, 2016; Piršl, 2016). By promoting these values, the education process enables learners to accept and respect different cultural identities and their coexistence in a particular community. The main task of intercultural education is to develop respect for diversity and human rights. Intercultural education supports diversity in all forms of human life, promotes equality and human rights. At the same time, it opposes discrimination, segregation, and disrespect.

The education system is responsible for shaping and developing cultural identity, just as it is responsible for the conceptualization of educational indicators of cultural identity.

It is important to encourage intercultural dialogue between the nations and national minorities of BiH and to develop sensitivity towards diversity. The main aim is to build peace and coexistence, and to raise awareness of the multicultural wealth of BiH society.

Educating Science Teachers for All

Cultural and linguistic diversity in the education system of BiH encouraged cooperation with international partners within the Erasmus+ CBHE project Educating Science Teachers for All (ESTA). One of the project goals is to share knowledge and skills with in-service and pre-service science teachers and thereby contribute to more inclusive and higher-quality science teaching. The innovative aspect of these courses is their interdisciplinarity: educators from science disciplines collaborate with educators from languages, general pedagogy, and intercultural education to create new instructional materials, with the intention of improving learning outcomes.

EXPERIMENTAL

As part of the project, a training program was organized for chemistry teachers from primary and secondary schools, with the aim to achieve the goal of sharing knowledge and skills with in-service science teachers. Activities within the courses were planned according to the aims of the ESTA project. The idea of CLIL (Content and Language Integrated Learning) was followed, which focuses not only on students' linguistic skills but also on their intercultural competencies. There is evidence that this approach has benefits in the teaching and learning of chemistry (e.g. Nurdillayeva and Zhuman, 2021, Nurdillayeva, Baisalova, Zhuman, 2020, Nikula, 2015).

Research questions

According to the aims of the ESTA project, the following research questions were formulated:

RQ1: What are in-service teachers' expectations from professional development (PD) program regarding cultural and linguistic diversity?

RQ2: What are in-service teachers' experiences regarding cultural and linguistic diversity in their classroom?

RQ3: What are the benefits of PD program implemented within the project and how it can be upgraded?

Instruments

The prerequisite for enrolling in the program was to fulfil an initial questionnaire (QI) that contained 36 questions about participants background (age, education level, mother tongue of them and their students, language of the literature they use to prepare lessons etc.). The QI was administered online, along with an invitation to the course sent to the corresponding ministries of education in Republic of Srpska (RS) and three cantons in Federation of Bosnia and Herzegovina (FBiH): Sarajevo Canton, Zenica-Doboj Canton and Central Bosnia Canton.

After attending and completing all requirements within the course, participants were asked to complete a paper-and-pencil questionnaire (QC), which contained 19 items about their impressions of the PD program and their perceptions of linguistically and culturally diverse material and its applicability in their teaching practice.

Participants

A total of 58 primary and secondary school chemistry teachers completed the QI, while 14 primary and 24 secondary school teachers attended and completed a two-day course held in November and December 2021 for primary school teachers and in May and June 2022 for secondary school teachers. There were still certain restrictions and precautions due to the COVID-19 pandemic, which explains the lower number of participants of the courses comparing to the number of teachers who filled the QI. The participants were divided into groups based on the data from QI, so that the groups were heterogeneous with respect to mother tongue. Each group consisted of at least one person proficient in English and IT in chemistry teaching, so that communication and cooperation that arose from the need to solve a common problem was at a high level.

About the courses

Participants were offered carefully planned activities (lectures, discussions, and workshops) aiming to develop knowledge, skills, and attitudes about (1) key concepts of intercultural education, (2) values of the intercultural dimensions and their integration into the educational process, (3) awareness of science and cultural capital and their role in the classroom, (4) the philosophy of nonviolence and nonviolent communication (an example of a conversation between a giraffe and a snake (Rosenberg, 2006)). Communication between participants was encouraged through group work.

During the course, the teachers were introduced to the basic linguistic characteristics of all three official languages in BiH, their similarities and differences at the grammatical and lexical linguistic level. The emphasis was set on the terms related to science/chemistry, which can affect the process of acquiring chemistry knowledge, and thus the achievements of students. Participants were encouraged to describe how they felt while reading a text in a language and script they rarely use. Those who have already had the opportunity to teach in linguistically diverse environments shared their experiences and pointed out the challenges they encountered.

Laboratory exercises were designed for the target group of participants (applicable at the primary and/or secondary level of chemistry education, depending on the group). The concept was based on the fact that each group receives a new exercise in a different language/alphabet or as a visual material. Additionally, the laboratory part of the course included the application of modern, digital laboratory and IT equipment (laboratory sensors for pH, temperature and conductivity, tablets and the corresponding applications for data collection and analysis).

Two experiments were selected from the teaching material *Lilu's House: Language Skills through Experiments* (2018): *Lilu, Alina and the Scientific Experiment* and *Lilu, Alina and Scientific Models*, based on their connections with current chemistry curriculum for primary schools. They were adapted with respect to the linguistic diversity of the participants (primary school chemistry teachers). Two experiments were prepared with the aim to use tablets and laboratory sensors: *Energy from food* and *Investigating Physical and Chemical Changes of Matter*. They were also adapted to another group of participants (secondary school chemistry teachers).

As laboratory part of the course required written material for the participants, it was delivered in different languages and/or alphabets (Bosnian, Croatian, Serbian, English, pictures; Latin or Cyrillic), in order to sensitize the participants to how the learning process can be hindered if the material was delivered to the students in a language or alphabet they are not familiar with.

Images support the development of students' language skills. Analyzing pictures offers an opportunity for meaningful student-to-student engagement because our perception of what we see is subjective. Genuine communication occurs during this type of oral exchange (Baker, 2015).

Before performing the laboratory exercises, the participants should (1) recognize the language standard used, (2) notice the linguistic features of the text, (3) find linguistic forms that might cause difficulties for students in understanding the content, and (4) offer synonyms for the forms found in the text. The goal was to familiarize the participants with the features of language standards in BiH, but also to develop sensitivity for students stemming from different linguistic backgrounds. This can result in planning an adequate teaching process for students in heterogeneous environments.

RESULTS AND DISCUSSION

The initial questionnaire (QI) that was applied with the invitation for the PD program, showed that a large number of teachers filled out the questionnaire using language forms characteristic only for certain language systems (e.g. *hemija* for Bosnian and Serbian; *kemija* for Croatian). Only a few teachers entered both language forms (e.g. *hemija/kemija*), thus respecting the culture of other language standard in Bosnia and Herzegovina. This indicated that some teachers are familiar with teaching in a linguistically heterogeneous environment, and that to a certain extent they have a developed sensitivity towards students who come from different speaking backgrounds. However, as pointed by Duverger (2007), teachers of "non-linguistic subjects" (such as chemistry) are not language teachers and therefore require specific training to apply CLIL (Jameau and Le Henaff, 2018).

There were 32.7% of participants with teaching experience up to 5 years. The second group consists of teachers with 20 and more years of experience (25.9%), while the other three groups (5-10, 10-15 and 15-20 years) were represented by 12-15%. More than 36% of teachers stated that they often teach students who speak a different mother tongue, while 17.2% stated they never had this opportunity.

The language of the literature that these teachers use to prepare for classes is represented in Table 1 (Likert-type questions, 5 - everyday, 1 - never).

Table 1: Literature used for preparing the class

Language	M*	SD**
Bosnian	4,26	1,09
Croatian	4,14	1,02
Serbian	3,22	1,43
English ¹	2,84	1,41

*M – mean, **SD – standard deviation

Teachers also stated that their knowledge of the Cyrillic alphabet is at a high level ($M = 4.36$, $SD = 0.97$). This was relevant because in the cantons to which the invitations were sent, Latin alphabet is dominant in the education system. Likert-type questions were also used to explore what types of teaching resources teachers use.

Table 2: The frequency of using different teaching materials and aids

Type of teaching material/aid	M	SD
Visual (schemes, pictures, photos)	4,57	0,53
Videos (e.g. YouTube)	3,90	0,85
Mobile/tablet apps	3,55	1,13
Other types of IT	4,00	0,99

Static visual teaching aids are most frequently used, while teachers rarely encouraged the use of mobile or tablet applications.

At the beginning of the course, the participants were asked about their expectations from the program they are attending, the lecturers, and themselves. The results are presented in Table 3.

¹ English and other foreign languages

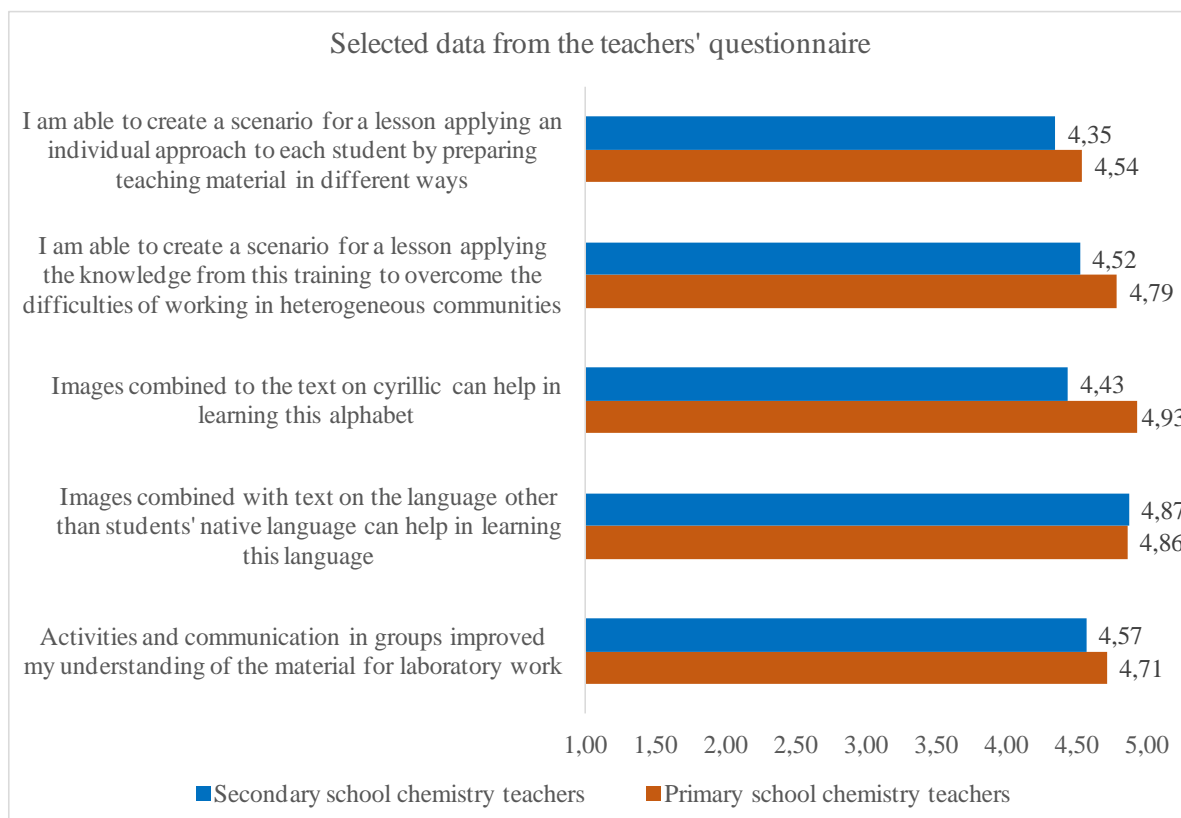
Table 3: Expectations of course participants

Type	Expectation
From the training program	To learn new knowledge and skills
	To improve acquired knowledge
	To experience new methods and forms of teaching
	To improve pedagogical and didactic skills
	To familiarize with the basic principles of intercultural education
	To learn from innovative and inspiring teaching materials
	To make a new friendship and exchange experiences with colleagues
From the ESTA project team members	Competence
	Interesting and creative contents
	Examples of good teaching practice
	Support with the challenges of teaching in heterogeneous groups
From the participants themselves	Respect for the needs and interests of the participants
	Active participation during the training program
	Application of the new knowledge in teaching
	Commitment and willingness to cooperate
	Success during the training program
	Enjoy activities and socializing with colleagues

These findings are consistent with the relevant scientific literature that explores teachers' expectations of in-service professional training programs, mostly highlighting relevant themes (Avidov-Ungar, 2020), as well as interactive learning and classroom applications

possibilities (Armour and Makopoulou, 2012; Bellibas and Gumus, 2016).

Participants filled out the QC after finishing the course's prerequisites. Selected results are represented in Figure 1.

**Figure 1:** Selected findings from teacher questionnaire Qc

There were no significant differences in responses between primary and secondary school chemistry teachers. Their positive impressions allow us to further develop teaching materials, as well as collaboration with teachers, both in- and pre-service. Teachers largely agree that the combination of images with Cyrillic alphabet or with a foreign language can improve a student's learning of the alphabet/language.

They also indicated that group activities and communication among group members helped in understanding the material for laboratory exercises. Perhaps the most important findings point to the abilities they developed during the courses to create adequate scenarios for lessons, with implementation in heterogeneous classrooms.

It is worth mentioning that all participants have positively evaluated the training program: the relevance of content, working conditions, quality of activities and engagement received $M \geq 4.87$ (on a 1-5 Likert-type scale). For the most part, they had no suggestions for upgrading the courses; some of them highlighted that they are pleased with sufficient amount of laboratory exercises applicable in the classroom, since they are not often implemented in PD courses.

Some examples of the ignorance of spelling rules common for all three official language standards in BiH were registered on the written material they received from the participants. This points to the issues in language culture in general, which can further complicate the situation in heterogeneous classrooms. There is certainly a need for continuous professional development, both in the professional and in the linguistic domains.

One of the training activities was the participants' perceptions of themselves. Participants were asked to complete five sentences beginning with "I am". It is interesting that 90% wrote "I am a teacher" in the second or third sentence. This is significant information because it indicates that the participants generally accept and understand their role and reputation in society.

CONCLUSION

Intercultural education is a vital factor in understanding different cultures and establishing positive relations between people. Its primary aim is to ensure sustainable social and cultural development, especially for vulnerable individuals or groups. Teachers need to acknowledge and accept other cultures, as well as respect their own culture in order to apply these values and attitudes in education process. Competent teachers can create a positive environment for intercultural communication and develop intercultural sensitivity in their students (Mrnjauš *et al.*, 2013, Sablić, 2013, Piršl, 2016).

During the training, the participants were exposed to unexpected situations, such as reading material in a language they (often) do not speak. These and similar teaching situations aimed for the participants to develop intercultural sensitization to the differences they could encounter in their classrooms.

RQ1: In-service teachers' expectations from PD program regarding cultural and linguistic diversity do not differ from those found in the literature; the most important

outcome from PD program is the applicability in everyday teaching practice.

RQ2: During the discussion, some teachers shared their experiences of cultural and linguistic diversity in their classrooms. They mostly encountered at least one example during their teaching practice. However, they did not have clear instructions or knowledge on how to manage them in their classrooms prior to this PD program.

RQ3: The benefits of the PD program realized within the project are numerous. Participants clearly missed such programs during the COVID-19 pandemic. They appreciated the laboratory exercises applicable in their classroom, the offer of visits to their schools to disseminate tools, methods and devices, and the combination of various teaching methods during the program. Some of them stated that they would like more practical activities.

The participants had no major difficulties in understanding content written in Latin or Cyrillic, nor did they experience any other difficulties related to linguistic issues. The reason for this is that the educational system of the former Yugoslavia respected diversity in terms of language, so students who predominantly received their education in this system are familiar with linguistic diversity. However, they experienced certain difficulties and showed resistance to material written in English. At the same time, younger participants stated that they know less about the "other" alphabet (in this case, mostly Cyrillic). They also show less confidence when working on texts written in Cyrillic, but they were more comfortable with material in English. It is reasonable to expect that teachers who experience some degree of insecurity will consider this in their classrooms.

Since themes regarding cultural and linguistic diversity with an emphasis on science education are new in teacher education in our country, there is certainly a need to develop courses which address these issues, both for in- and pre-service teachers. This confirms that the goals of the ESTA project were relevant for contemporary science education.

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Summary/Sažetak

Jedan od izazova u nastavi prirodnih nauka u Bosni i Hercegovini jeste pluralizam jezika i kulturološka raznolikost. U dosadašnjem inicijalnom obrazovanju nastavnika nedostajalo je kvalitetne pripreme za ove suvremene izazove; prilike za poučavanje kulturne i jezične raznolikosti nisu bile prepoznate. Stoga je izazov potaknuti iskusne nastavnike kemije da razviju kompetencije za interkulturalno nastavno okruženje, a što je jedan od ciljeva u okviru projekta Educating Science Teachers for All (ESTA). Polaznici programa stručnog usavršavanja bili su nastavnici kemije iz tri kantona u FBiH. Program je imao za cilj razvijanje i unaprjeđenje stručnih kompetencija kroz radionice i grupni rad, uz raspravu o odabranim temama i laboratorijske vježbe uz korištenje suvremene laboratorijske opreme i informacijsko-komunikacijske tehnologije. Ponuđene su mogućnosti poučavanja u jezički raznolikim razredima, kao i u razredima s drugim oblicima različitosti učenika. Rezultati su pokazali da su nastavnici svjesni potrebe senzibiliziranja za različitosti učenika. Izrazili su pozitivne dojmove i spremnost da nastavne materijale prilagode potrebama svojih učenika, ali i potrebu za daljnjom podrškom kroz suradnju sa univerzitetskim nastavnim osobljem.