

Understanding of Sustainability and Education for Sustainable Development among Pre-Service Biology Teachers

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Abstract.

Sustainable development (SD) is one of the global and central aims of today's politics. As stated in Agenda 21, education has to play an essential role in achieving a sustainable society. The present research focused on Slovenian and Austrian biology teacher students' understanding about SD and education for sustainable development (ESD), and on their pedagogical content knowledge (PCK) in these issues. The research was carried out at the University of Ljubljana, Faculty of Education and at the University of Vienna, Centre for Teacher Education. Altogether, sixty Slovenian and sixty Austrian pre-service biology teachers were interviewed. Pre-service biology teachers answered a set of closed, Likert-type and open survey-questions. Pre-service biology teachers from Slovenia and Austria had a good understanding of the environmental aspects of sustainability, but they lack understanding the interconnections between the environmental, economic and social concerns related to SD. They describe and connect ESD with environmental education and environmental awareness. Students from both countries know the pedagogical principles of ESD, such as active learning and transformative education. Results of the research contribute to evaluation and development of curriculum for middle and high school biology teachers.

Keywords: attitudes, knowledge, pedagogical content knowledge, pre-service biology teachers, sustainable development

1. Introduction

One of the most important goals of humanity in the 21st century is to construct a sustainable society. Education is one of the keys to achieve sustainability. The term sustainable development (SD) was first published in the late eighties. Mostly known is Brundtland's definition of SD: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Conference on Environment and Development, 1987, p. 43). This concept has received the most attention since the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992. The key document of the Rio agreement is called Agenda 21, a major action plan for SD in the 21st century (Palmer and Neal, 1994). Nowadays, SD is the theoretical basis and an increasingly important norm for human development worldwide (UNESCO, 2009).

Education for sustainable development (ESD) is one of the main aims of the national as well as international school policies (UNESCO, 2005). ESD was first mentioned by Chapter 36 of Agenda 21, where four main aims of the work of ESD were described: improve basic education, reorient existing education to address sustainable development, develop public understanding, awareness, and training (Agenda 21, Chapter 36).

We can find many models of how to include ESD into general teaching and biology education. All these models have a multi-level process. Models include societal issues (local, regional, global levels), inter- and multidisciplinary approach as well as changes in pedagogy. ESD teaching is a combination of different views: socially relevant topics, biology in combination with chemistry and/or physics and three pillars of sustainability: social, economic and ecological. The aim of teaching follows a skill orientated paradigm (Padem, 2000). Topics in the context of a sustainable future are biodiversity, climate change, the sustainable use of natural resources, health, cultural heritage, multiculturalism, global welfare (UNESCO, 2005). One of the main critical issues for teachers is to discuss with students about the effects of students' behaviour and sustainable practice in the local environment. Other important goals are to learn negotiation, problem-solving and decision-making skills through discussions about ecological, social, economic, and ethical principles concerning local and global responsibility in their own life. It is essential to present biology as action-oriented science education, where students are engaged in socio-political actions and start making a change (Maina, 2004; Wood, 2009). Understanding SD and ESD are nowadays one of the critical competencies for future biology teachers (Österreichische Strategie zur Bildung für nachhaltige Entwicklung; 2008; White paper on education in the Republic of Slovenia, 2011). From the curricula for biology in Slovenian lower secondary school (8th and 9th grade), we figured out that SD is mentioned in the 9th grade in context of Biology and society and Human impact on the environment (Učni načrt za biologijo, 2011). In Austrian curricula for biology and environmental education, we investigated that SD is mentioned in all of four grades of lower secondary school in the context of Human and Health, Animals and Plants, and Ecology and Environment (Biologie und Umweltkunde, 2000).

As far as we know, no previous research has investigated the understanding of sustainability and ESD among student teachers of biology in Slovenia and Austria. Slovenian researchers already studied understanding of SD in kindergartens (Lepičnik et al, 2011) and among future primary school teachers (Skribe Dimec, 2013). Students' views on the acceptability of their teachers' value-related statements about sustainability and climate change were studied by Torkar (2013). Austrian researchers report about competences for ESD in teacher education (Rauch & Steiner, 2013). Pfaffenwimmer and Rauch (2014) studied networking for innovation in ESD in the school system in Austria. In international studies, we could find more studies among student teachers and their understanding of sustainability and ESD. Summers et al. (2004) analysed subject matter knowledge of science teacher trainees regarding SD in the field of geography. Burmeister and Eilks (2013) described the understanding of sustainability and ESD among German student teachers and trainee teachers of chemistry. Jeronen et al. (2016) researched teaching methods in biology education and sustainability education, used to promote sustainability. Researchers recognised positive attitudes towards concepts of SD and ESD, but also the lack of knowledge.

The main contribution of this study provides an understanding of students' attitudes and knowledge about SD and ESD among pre-service teachers of biology in Slovenia and Austria. Results of the research will be used to evaluate and develop a curriculum for pre-service biology teachers in middle and high schools.

2. Methods

The research was based on descriptive and causal non-experimental research methods. In this research, qualitative and quantitative methods were used. A questionnaire was used to collect data.

2.1 Research problem

The aim of the study was to identify understanding and knowledge about SD and ESD among Slovenian and Austrian pre-service biology teachers, and compare the results between the two countries. The research also focused on the pre-service teacher's PCK; i.e. how students plan to implement ESD in their future biology teaching?

2.2 Instrument

The questionnaire developed by Burmeister and Eilks (2013) was used. The questionnaire was originally developed in German language and for chemistry teachers. Therefore, it was modified in order to serve for pre-service biology teachers, moreover it was translated to Slovenian language. The questionnaire included open and closed questions with Likert-scale. In the first part of the questionnaire, pre-service teachers wrote the general information about their age, study programme, and level of education. In the second part, students wrote their word associations and explained understanding of the terms SD and ESD. The third part of the questionnaire focused on theories of sustainability and ESD and their sources of information. The last part of the questionnaire focused on students' PCK concerning sustainable development.

2.3 Sample and Settings

Pre-service biology teachers from the University of Ljubljana and the University of Vienna participated in the research. The first sample was sixty students from the University of Ljubljana, Faculty of Education, Department of Biology, Chemistry and Home Economic. The second sample was sixty pre-service biology teachers from the University of Vienna, Centre for Teacher Education.

The study was conducted in May and June 2018. Students completed the anonymous questionnaire in 15 to 20 minutes. Firstly, the instructions and the general goals of the research were presented to students. The sample was non-randomly chosen. From the University of Ljubljana more than 80% of future biology teachers from 3rd and 4th year of Bachelor study and Master study were reached. At the University of Vienna, Centre for Teacher Education, the same number of future biology teachers represented less than 40% of future biology teachers from 3rd and 4th year of Bachelor study and the outdated Diploma study (this is the study program before the Bologna programme was implemented). Student teachers from Slovenia and Austria had different second subjects (Figure 1). Slovene students at the University of Ljubljana can select Home Economics or Chemistry as second subject. In the sample, 52% of students selected Home Economics and 48% students Chemistry. At the University of Vienna, the study program for biology teachers is called Biology and Environmental Education. Students can choose it in combination with one of 27 other subjects. The most popular combination was with geography, psychology and philosophy (15% of students per each combination). For further details see Figure 1.

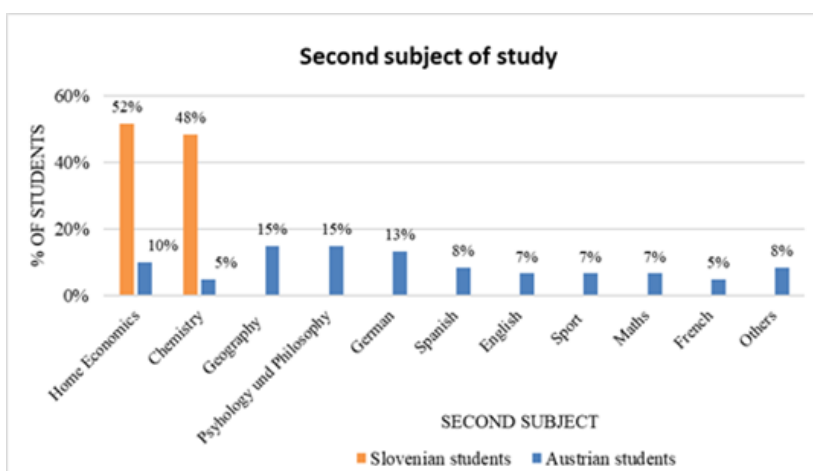


Figure 1: Second subject of study

2.4 Data analysis

All data from the questionnaire were digitised and translated from Slovenian and German language to English. Firstly, the closed and Likert questions were analysed using statistical program IBM SPSS Statistic, version 24. Data obtained from the questionnaire was processed on the level of descriptive and interfering statistic, using the following statistic methods: T-test for Independent Samples and a chi-square test were used to compare the differences between Slovenian and Austrian students' knowledge and attitudes. The level of significance is 0.05, the corresponding confidence level is 95%. Secondly, open questions were coded. Coding is the interpretive process by which data is broken down analytically (Corbin & Strauss, 2008). Deductive and inductive coding methods were used. Data (associations/words/sentences) with

the same meaning were coded together. In our research, data that appeared less than three times per question were not coded. This presented 2% of all the answers. The frequency of the codes in each category was calculated. Some of the terms studied (i.e. sustainability and understanding SD) were operated using the categories suggested in Burmeister and Eilks (2013). Some categorisations were later redefined and added, based on data material and theoretical framework. For other open questions, categorisations were created based on the data materials and literature review.

3. Results and discussion

One of the primary purposes of the education system worldwide is to develop insights into different aspects of sustainability that go beyond the understanding of environmental problems. The following chapters report the current situation on the matter among pre-service biology teachers in Slovenia and Austria.

3.1 Sustainable development (SD)

Data obtained from students' answers to word "sustainability" were coded into categories presented in Figure 2. Students were strongly linking the term sustainability to environmental aspects and rarely to economic and social aspects. They emphasized three main categories of conceptions: time issue in relation to sustainability, an educational issue, and they gave their definition of sustainable development. Some responses are mentioned only in one of the two cohorts. Slovenian students mentioned green chemistry, European Union, home economics and competences. Meanwhile, Austrian students gave answers such as ecological footprint, vegan and vegetarian lifestyle, environmentally friendly, environmental organisation, wildlife conservation, rainforest protection, local products, seasonal products, agriculture and GMOs, global thinking and first world vs the third world. Differences in associations between the two cohorts could be associated with the curricula, the second subject of study, content knowledge and the influences of mass media in the countries. Especially the second subject of study varies a lot between Slovenian and Austrian students and may contribute to the differences in conception of sustainability. Slovenian students can study biology with either home economics or chemistry. Most of the Austrian students combine biology studies with one of the social science subjects. These basic findings are consistent with findings by Hagevik et al. (2015). They report that elementary science teachers' have a lack of understanding of the interrelations between different approaches of sustainability. Summers and Childs (2007) reported quite similar results in their research among English student teachers of science and geography, and Uitto and Saloranta (2017) found similar sustainability dimensions among Finnish lower secondary school teachers. They report that science teachers, especially biology and geography teachers, considered the ecological sustainability aspect more than economic or social ones.

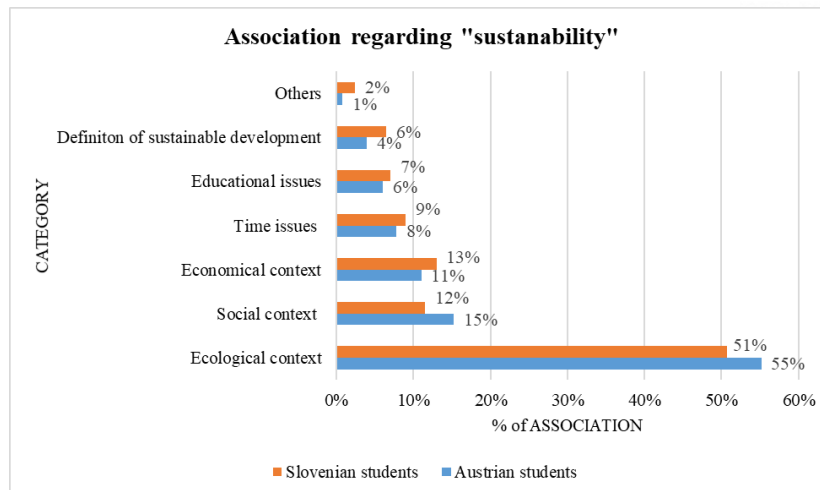


Figure 2: Slovenian and Austrian students' associations about the term "sustainability" in the main categories

Slovenian and Austrian students knew environmental problems quite well (Figure 3). Nearly 70% of students from both cohorts explained SD in connection with ideas taken from the concept of SD; i.e. all three aspects of sustainability or/and inter-generational equitability. Typical answers were: *“The development over time (over generations, etc.) that goes in the direction of sustainability/pursues sustainable goals.”*, *“Respecting our environment. Not harming nature.”* or *“Conscious handling of food, eating regional products, no plastic dishes, no aluminium foil.”* Less than 5% of Slovenian and Austrian students showed a comprehensive understanding of the term sustainability. Typical answer was: *“Development in way that is good for society and nature now and for future generation”*. Similar findings were reported by Burmeister and Eilks (2013) in their study among German student teachers and trainee teachers of chemistry.

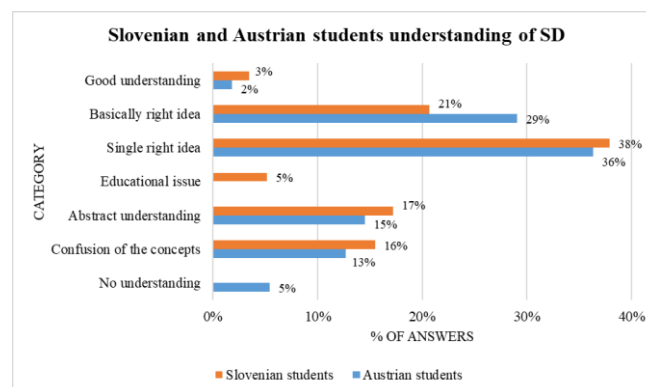


Figure 3: Slovenian and Austrian students understanding of SD

4.2 Education for Sustainable Development (ESD)

ESD is an approach to education, which includes an integrative and holistic view, linking knowledge and action. Students were asked to explain how they would define/describe the ESD. Figure 4 shows that students had an abstract understanding of the ESD, linking it to environmental education and describing pedagogical approaches. Abstract understanding means that students mentioned few ideas about education and sustainability. Ideas were general and not clear. Exemplary answers were: *“Teaching about ESD, following the trends in*

education.” or “To bring the so-called concepts closer to everyone, especially in school.” Most of the students from Slovenia defined the ESD as environmental education. Meanwhile, most students from Austria defined it as a pedagogical approach for teaching about the SD. Environmental education was described as learning about environmental protection and creating environmental awareness. Exemplary answers were: “Activating awareness and making people aware of problems that affect the future of our environment.” or “Paying attention to environmental influences that are bad for the environment! Everyone can do something! Ecological Footprint → Create awareness!” The pedagogical approach was defined as teaching methods that were recommended by the ESD (e.g. lifelong learning, working with students’ values and competencies, rethinking and alternative actions, learning by case studies etc.). Exemplary answer was: “Sustainable thinking lives on a holistic level and must include the world in which the students live. Therefore, sustainability issues need to be communicated to students on a holistic level.” When comparing our results to Burmeister and Eilks’s study (2013), it must be pointed out that Slovene and Austrian students were able to more clearly outline the aims and pedagogy of the ESD. This could be a consequence of the UNESCO decade because the previous study was at the beginning while this study was carried out after the decade.

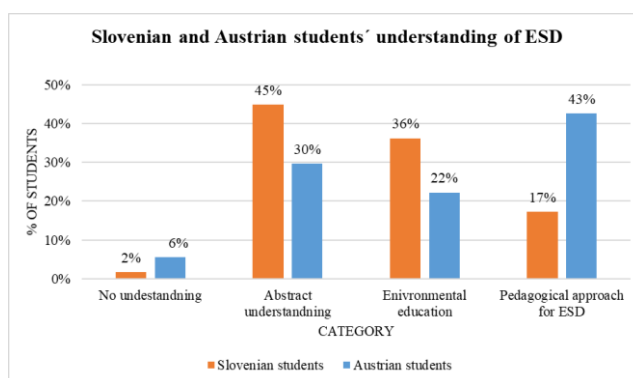


Figure 4: Slovenian and Austrian students' understanding of ESD

Students were asked which school subjects might be best for promoting ESD in school. Figure 5 shows that the participants acknowledged the significant role of natural science subjects, more than 50% students in the research (i.e. biology, chemistry, physics), followed by science subjects (i.e. geography, languages) and interdisciplinary subjects (e.g. home economics). Biology was the most frequently mentioned subject in both cohorts. Austrian students more often preferred social science subjects. This may be connected with their choice of the second study area (more than 70% of Austrian students had chosen social science subject as their second subject area). Students from Slovenia more often preferred chemistry or home economics as did students from Austria. Geography was the most often mentioned social science subject in both cohorts. The majority of the participants mentioned the subject, which was their study area.

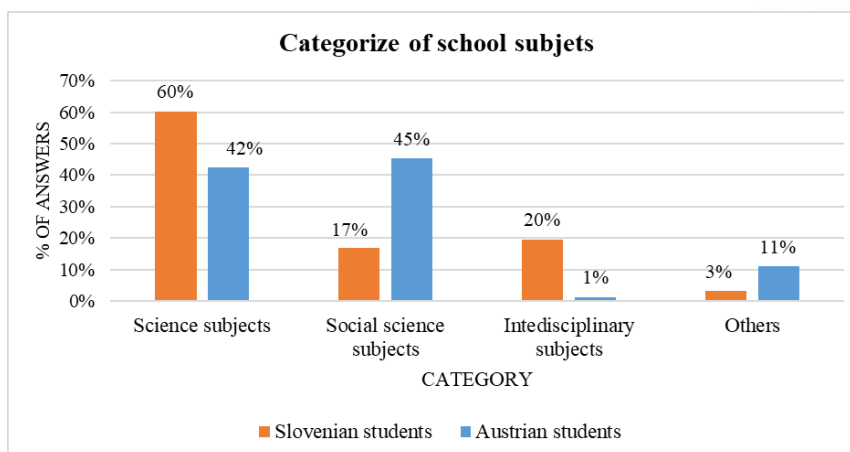


Figure 5: Category where students placed ESD

Figure 6 shows that students from Slovenia and Austria significantly differ regarding implementation of ESD in upper secondary school ($t = 2.450$, $df = 118$, $p = 0.016$). In this regard, more Slovenian students ($M = 3.70$, $SD = 0.619$) want to implement ESD in upper secondary school than Austrian students ($M = 3.25$, $SD = 0.895$). No statistically significant difference was recoded between Slovenian and Austrian students' attitudes to implementing ESD in lower secondary school ($t = 1.233$, $df = 118$, $p = 0.220$) and their own class ($t = 0.875$, $df = 118$, $p = 0.383$). Students in both cohorts showed high levels of support of the importance of ESD in general in society, and in biology education.

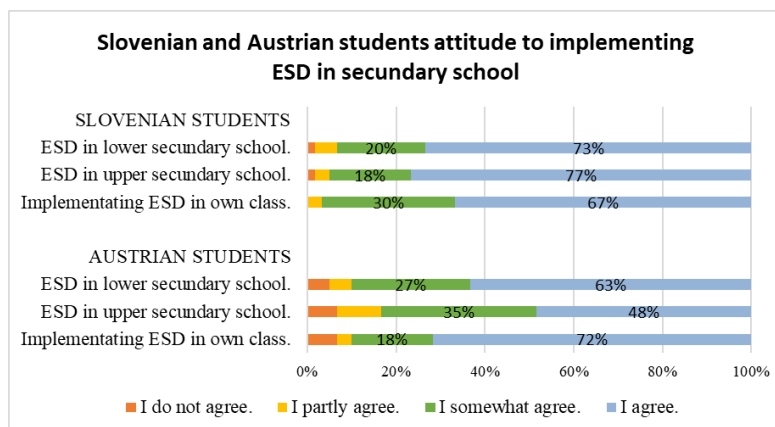


Figure 6: Slovenian and Austrian students' attitude to implementation ESD in secondary school.

3.1.Sources of knowledge about ESD

Students' reflection of the source of knowledge showed differences between Slovenian and Austrian students' answers (Figure 7 and 8). More than half of the students from both cohorts heard about three pillars of sustainability from biology study. The statistically significant difference between the cohorts from biology subject was found in Brundtland's definition and ESD. Approximately 40% of Slovenian students and 60% of Austrian students remembered Brundtland's definition from biology study. Approximately 20% of Slovenian students and 50% of the Austrian students heard about ESD from biology study. The statistically significant difference between the cohorts from biology subject was found in Brundtland's definition and

ESD. More than half of Slovenian students heard about the meaning of sustainable development from the second subject, while sixty percent of Austrian students' heard about it in biology. Slovenian students select biology with either home economics or chemistry, which are both strongly connected to sustainability issues. In both of those subjects, students have courses, where they learn about sustainability. For example, pre-service biology and home economics teachers at the University of Ljubljana, Faculty of Education attend the compulsory subjects Consumer Education and Population and Environment. They also can attend elective courses like Environment and Sustainable Development. Austrian students can select among 27 second subject areas; more than 70% of those are social science subjects. Some of them like geography includes many courses about sustainability issues. Similarly, Austrian students mentioned biology subject as a main source of knowledge about ESD, while the second subject is emphasized more in Slovene cohort. Other sources, such as mass media, have been found to be an influential channel of information for students. These finding ties well with previous studies wherein Burmeister and Eilks (2013) reported that the most often mentioned sources of information were sources outside of the university.

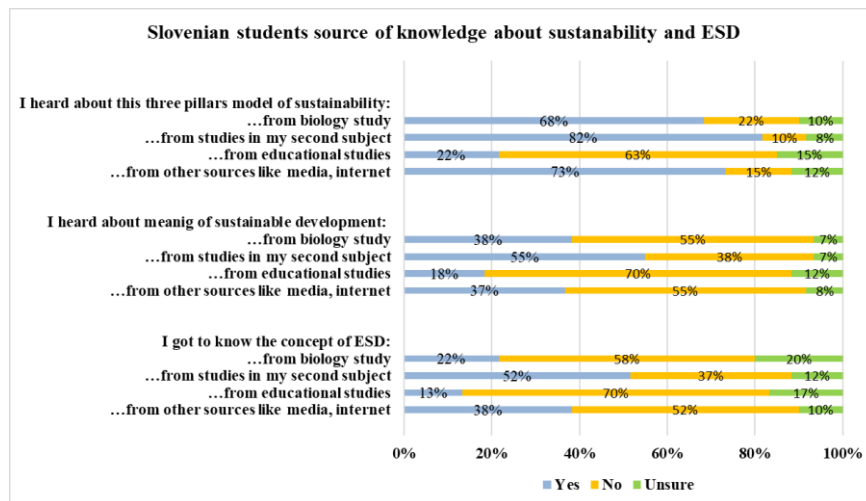


Figure 7: Slovenian students' source of knowledge about "sustainability" and ESD.

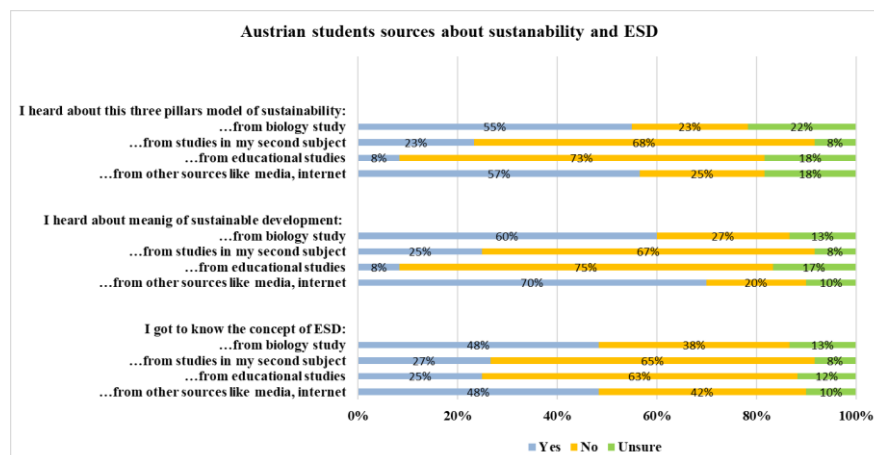


Figure 8: Austrian students' source of knowledge about "sustainability" and ESD.

3.2. Pedagogical Content Knowledge (PCK)

This last section discusses the students' PCK. Studies showed that a broad and deep understanding of the PCK is a key aspect for successful interdisciplinary collaboration and a holistic view on sustainability (Sterling, 2004). Knowledge about the curriculum is an essential aspect of PCK. Students were asked about topics and contents in biology curriculum relevant for teaching ESD. Environmental issues and ecology were the most often mentioned school topics in both cohorts. Students strongly connect SD and ESD to environmental aspects (Figure 9). Slovenian students mentioned some topics, like ecology and molecular biology more often, while Austrian students more often mentioned topics from agriculture and global world. The reason for differences may origin in the curriculums on all levels of education, from primary school to university. By comparing the results to Burmeister and Eilks (2013) students in our study showed broader knowledge. The mentioned topics were more cross-curricular and interdisciplinary. However, when comparing our results to those of older studies in biology and environmental education, it must be pointed out that overall the results are quite similar. Peer et al. (2007) revealed a lack of knowledge and missing conceptualisation for environmental education among Israeli pre-service teachers, even though the students' attitudes towards the subject were quite positive. Esa (2010) researched ESD among pre-service biology teachers from Malaysia. She explained the high support to implement ESD in biology education, but on the other side provided a better understanding of the pedagogies for sustainability.

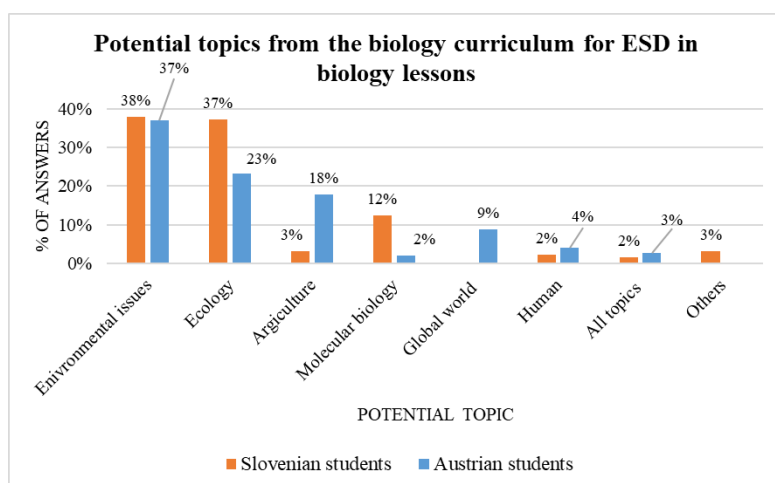


Figure 9: Potential topics from the biology curriculum for ESD in biology lessons.

The main purpose of ESD is changing education from transmissive to transformative teaching and learning. We asked students about suitable teaching approaches to teach ESD. Students most often mentioned single teaching methods; sometimes they mentioned also teaching forms as well as teaching approaches. Students' answers from both cohorts are similar. Most often was mentioned a learners' centred approach, approximately 60% of students in our cohort; teacher's centred approach was mentioned by approximately 30% of students. Students' answers in category learners' centred approach were such as project-based learning, experiments, learning outside of classroom and cooperative learning. Active learning processes were common in those approaches. Students showed understanding of transformative education quite well. The results reflect the methodological approach of the courses at the Universities and the students' previous experiences from primary and secondary schools. In this study we investigated only students' perceptions of pedagogical approaches for ESD. For the further

studies it would be interesting how students implement the pedagogical approach for ESD in their teaching.

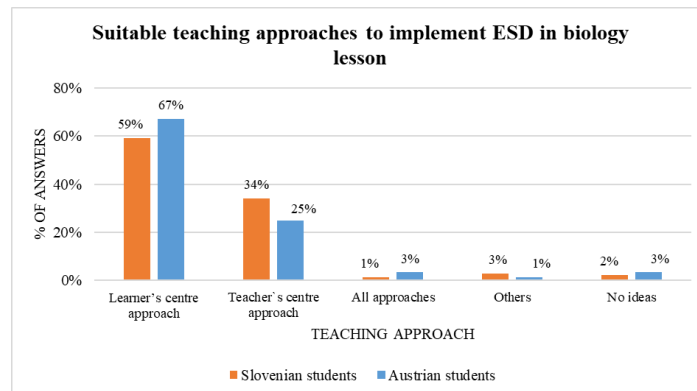


Figure 10: Suitable approaches to implement ESD in biology lesson.

4. Conclusion

Pre-service biology teachers in Slovenia and Austria understand SD in connection with ideas taken from the Brundtland concept of SD; i.e. all three aspects of sustainability or/and inter-generational equitability. There are no major differences between students from the compared countries in their conceptions about SD. They had a good understanding of the environmental dimension of sustainability, but a lack of interconnections between the environmental, political, economic and social concerns related to sustainable development. Similar conclusions can be made for their understanding of the ESD. They describe ESD as an approach to education, which includes integrative and holistic view, linking knowledge and action. There are no major differences between Slovenian and Austrian pre-service biology teachers. They describe and connect ESD with environmental education and environmental awareness. Only a few students possessed clear, theory-supported concepts about SD and ESD. Pre-service biology teachers report learning about the concepts of SD and ESD from courses in biology studies, the second study subject, and from the mass media. For pre-service biology teachers in Slovenia the second subject of study (chemistry or home economics) was more important source of information about SD and ESD than for their colleagues from Austria. Pre-service biology teachers from Austria heard more about these concepts in the mass media. Students had various ideas about PCK. They know the basic pedagogical aspects of ESD, such as active learning and transformative education. This study can help authorities responsible for higher education to plan curriculum developments and devote more focus on research about SD and ESD among pre-service and in-service teachers. Very important finding of the present research, which should be further studied and elaborated, is the impact of the second study subject on pre-service biology teacher's understanding of SD and ESD. Interdisciplinary approach in the development of the curriculum of two subject school teachers would be beneficial, because SD and ESD are cross-curricular topics that can be addresses in natural sciences, social sciences and humanities. Furthermore, these findings can serve in planning of longitudinal research focusing on students' changes in understanding of SD and ESD from the first to last semester at the university. This will enable a better view of the impact that higher education programs have for university students' understanding of SD and ESD.

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