CURRICULUM FOR THE SUBJECT OF PHYSICS IN PRIMARY SCHOOL AND GYMNASIUM IN SLOVENIA

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Abstract
In Slovenia, physics contents appear from kindergarten curricula onwards. The subject of Physics is taught in grades 8 and 9 of primary school and in grades 1, 2 and 3 of the gymnasium. If it is chosen as a subject of general matura exam, students learn it also in grade 4. The article presents the comparison of curricula for the subject of Physics in primary school and for the subject of Physics in gymnasium and answers to research questions regarding similarities between primary and general secondary curricula structure and the assessment of the gained learning objectives from the curricula on the national level.

Introduction

Slovenia has three levels of education: basic, secondary and higher education. Students enter basic (primary) school at age six and visit it for nine years. Physics is taught in grades 8 and 9 of primary school. However, physics contents are part of curricula for different subjects in the lower grades as well. The subject of Environmental studies is taught in the first triad, Science and technology in grades 4 and 5, and subject Science in grades 6 and 7. However, The Expert Council for General Education of the Republic of Slovenia determines the subjects curricula [1]. Teachers have autonomy according to the teaching methods and textbooks.

At the end of the primary school, (in May in grade 9) students participate in the obligatory national assessment of knowledge. The achievements rarely play an important role in entering the secondary level education [2]. Three subjects are part of the national assessment, Slovene, Math, and the third subject. At the beginning of the school year 454 of primary schools, receive the information, which the third subject will be part of their national assessment [3]. In the group of third subjects are every year 5 subjects. The distribution of the schools according to the 3rd subject for the school year 2018/2019 is in Figure 1.

After successfully completed primary school, meaning achieving a general learning success in grade 9 satisfactory or better, students might enter programs of secondary vocational education, secondary technical and vocational education or general secondary education (gymnasium). In the following, the focus will be on the gymnasium. The programme of general gymnasium lasts four years, from 16 to 19-year-old students [1]. Physics is taught in grades from 1 to 3, however, if it is chosen as a general matura subject also in grade 4. Matura is a general external examination where the knowledge in five subjects is assessed. Three subjects are obligatory subjects - Math, Slovene, English - and two subjects are elective [5].

All detailed data about national knowledge assessment test in primary level and secondary level in general and per subjects, including the structure and description of the test, instructions, tests from previous years, solution, etc. are available on the webpage of the National examination center (Figure 2) [6].

The Matura is a school-leaving exam required for the completion of secondary education and for university entrance. At least satisfactory grades in all subjects in matura enable students to enter higher education programs on vocational college or university [5].

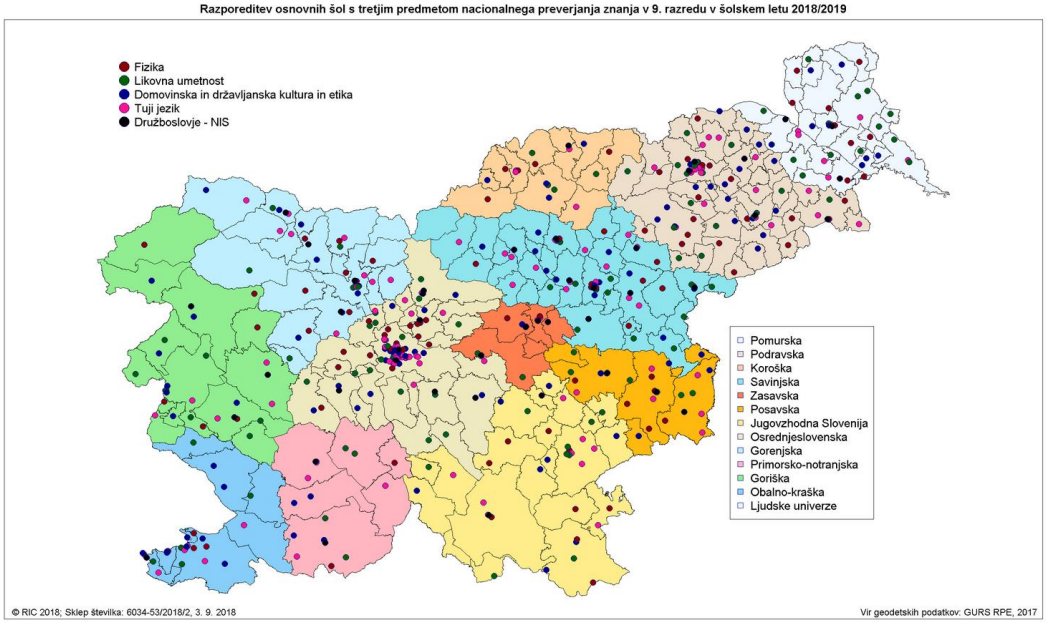


Figure 1. *The distribution of schools according to the 3rd subject in the national assessment of knowledge in the primary school. Third subjects in the school year 2018/19 are physics, art, homeland education and ethics, foreign language and social sciences [4].*

Figure 2. *The web page of the National examination center for the subject of Physics for matura exam. It includes information about the exam, subject catalogue knowledge in 3 languages (Slovene and Italian and Hungarian). The reports for previous general matura physics exam and tasks as well as solutions are available on the web page [7].*

The aims of the paper are to present the structure of the curricula of subject Physics for primary and general secondary school (gymnasium), what curricula offer and how the

achievement of the objectives is evaluated on the national level. However, with regard to the research aims, the following research questions can be addressed:

- Which similarities and differences appear in the curricular structure of subject physics for primary and secondary students?
- How students' knowledge of physics is evaluated on primary and general secondary level by national assessment of knowledge?

Methods

A qualitative research approach with descriptive methods was used in this research. For this purpose, the latest versions of curricula of subjects Physics for primary school and gymnasium were analysed according to the criteria covering research questions. Last adaptation of physics curriculum for the primary school that is currently valid was done in 2011 [8]. However, the curriculum for physics in the gymnasium was adapted in 2015 [9].

Results

Comparison of curricula of subjects Physics in primary school and Physics in the gymnasium

The curriculum for physics in primary school prescribes the number of school hours of the subject per school year. It is 70 hours in grade 8 and 64 hours in grade 9 [8]. The curriculum for physics in gymnasium prescribes 210 hours per 3 school years, if chosen for a matura exam an additional 140 hours in grade 4. Physics in gymnasium might be chosen also as an optional course [9].

The curriculum for physics in primary school has 5 chapters: Description of a subject, General objectives, Learning objectives and contents, Standards of knowledge, and Didactic recommendations [8]. On the other hand, the curriculum for physics in gymnasium consists of 9 chapters. Additional chapters are Expected outcomes, Cross-curricular integration (in the primary it is part of Didactic recommendations), Material conditions for teaching, and Knowledge of teachers.

An operational description of the subject is given in the curriculum. It is written: The teaching of physics as a fundamental natural science develops the student's ability to study phenomena in the field of physics and to adopt the language and methods that we use in studying the physics phenomena, and to become acquainted with the main physics concepts and theories that summarize our knowledge of the material world. The description of the subject stresses the development of abilities for studying science phenomena. Physics describes phenomena on all size levels. During physics, students should get familiar with technology acquisitions and technological processes. The role of physics in school also illustrates the connection of natural phenomena [8]. In the curriculum for physics in the gymnasium is added that gymnasium physics is an upgradation of physics (and math) knowledge from primary school and should be an appropriate basis for studying science and technology on tertiary level [9].

In the chapter General objectives (in the gymnasium the title is extended to General objectives and competencies) is written that students should, despite memorizing things, learn to master instruments, tools, and procedures. The objectives related to the evaluation of the gained information are emphasized as well. A detailed description of several competencies (digital, ICT, language, learning of learning, etc.) being developed during the physics lessons are discussed as well [8,9].

Learning objectives and contents are the most extensive chapter of the curricula. There are 12 topics (Table 1) with subtopics including the list of obligatory and elective learning objectives with remarks about the experimental work in the primary school physics curriculum [8]. In gymnasium 21 (Table 2) with the expected written learning outcomes [9]. Learning objectives and contents in the gymnasium are covered by general knowledge (labelled SZ), special knowledge written in italics, elective contents (labelled with I), and experimental work in the lab (labelled with EV). However, the recommended distribution of school hours in the gymnasium is following: 30 hours for gaining general knowledge, 15 hours for special knowledge, elective contents (I), optional contents by teacher's choice, project work, seminar papers, etc., 10 hours for experimental work and 15 hours for assessment [9].

Figures 3 and 4 represent the examples of the learning objectives in the topic of heat and internal energy in the primary school and the listed standards of knowledge. It is evident that the record is very detailed. Similarly, it is also obvious from Figure 5, where the learning objectives for the same topic from the curriculum of physics for gymnasium are presented. In the curricula for gymnasium, standards of knowledge are written under the objectives and not separately. In the curriculum for gymnasiums, immediately after the learning objectives, the standards of knowledge are listed.

According to the learning objectives, the general objectives and competencies thematic learning objectives and minimal standards of knowledge were formed. They are presented in the chapter Standards of knowledge in the primary school curriculum.

In the chapter Didactic recommendations for the primary school physics are written recommendations of school hour distribution per topics (Table 1), issues related to individualization and differentiation, cross-curricular integration, assessment, and ICT. School hour distribution is made for the around 40 school hours for topics, however, other school hours might be used for assessment, practicing, other objectives, project work, seminar papers, etc. At this point, the importance of the experimental work is emphasized. The curriculum for physics in gymnasium emphasizes the scientific method, active methods, instructions for demonstration experimental work in the chapter Didactic recommendations. However, the curriculum reminds a teacher on the students from different diapasons, e. g. gifted students, students with learning difficulties, students with deficits, foreigners. Cross-curricular integration might refer to contents, science processes and skills, learning and applying process knowledge as well as on the level of understanding the concepts that are common to science. In the curriculum for gymnasium it is a separate chapter [8, 9].

Physics knowledge and understanding in primary school and in gymnasium might be assessed with an oral exam, the written (not obligatory) exam, and other. A teacher might assess the experimental work, project work, preparation and presentation of papers, production of device models, etc. It is stressed that in the primary school half of the points on the exam has to be possible to reach without calculating and in gymnasium one-third of them. However, the exam has to cover the standard and minimal standard of knowledge. In the gymnasium, the student should be involved in the assessment process [8,9].

ICT has an important role in physics, covering from measuring devices for data acquisition and processing, e-materials, animations to the use of the web. However, the aim is that students become the independent users of ICT [8,9].

The chapter about the expected outcomes, in the curriculum for physics in the gymnasium, refers to the results after the 3rd year of physics. It covers the process

knowledge and skills (such as, the ability of complex thinking, mastering basic experimental skills, searching, processing and evaluating data from different sources), the ability to present projects, simple research or own ideas, the ability to work in teams or other forms of group work (different roles), learning of learning - planning and the ability to learn independently, and the development of the attitude toward the environment [9].

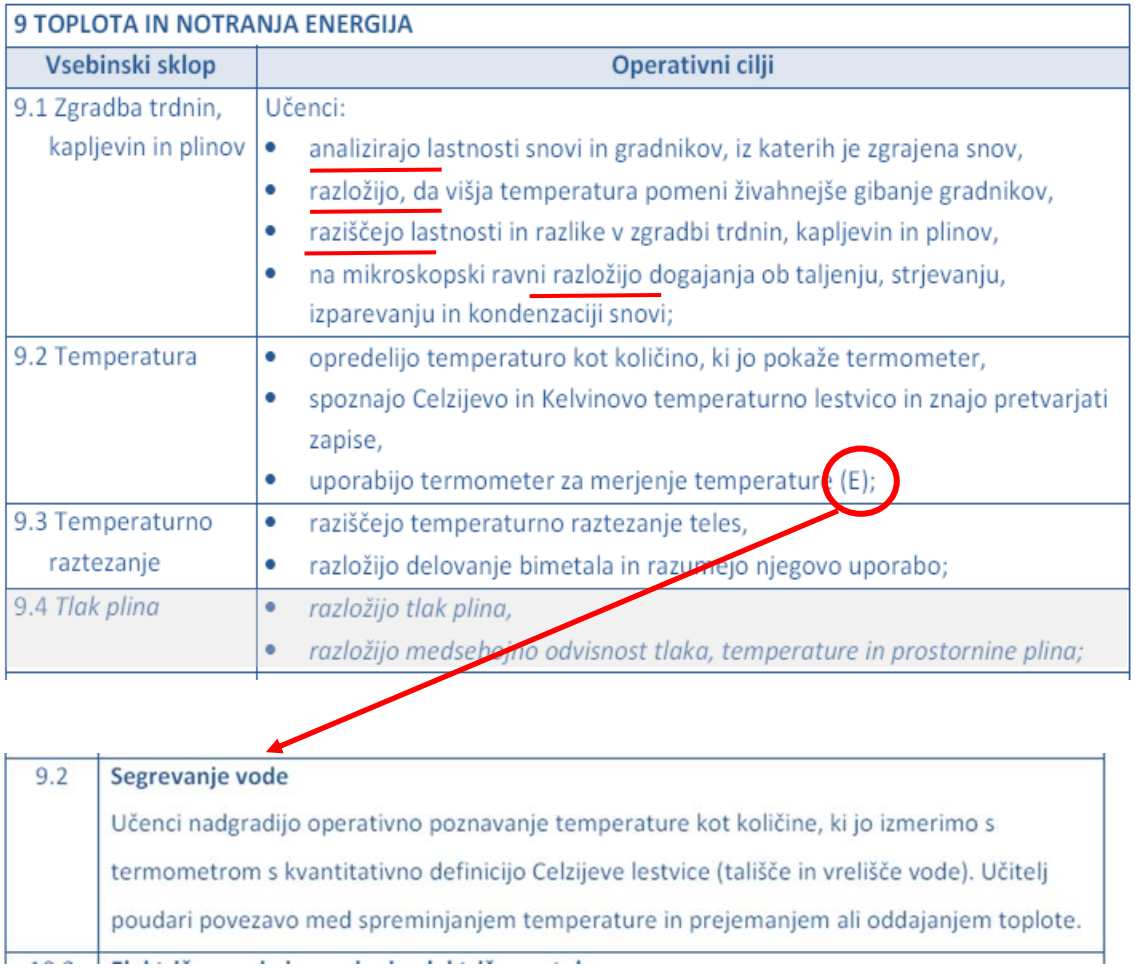
Chapter Material conditions for teaching in gymnasium curriculum describes the role of a technician at experimental work and the limit for lab work on 17 students. Who can teach physics in the gymnasium is also added in the curriculum in the chapter Knowledge of teachers [9].

Table 1. *The distribution of school hours according to the topics in the curriculum for Physics in primary school [8].*

Grade (number of school hours for topics/prescribed number of school hours)	*Topic*	*Number of school hours*
Grade 8 (43/70)	Introduction to physics (importance, measurement)	5
	Light	7
	Space	4
	Motion	6
	Forces	10
	Density, pressure, buoyancy	11
Grade 9 (43/64)	Accelerated motion and 2nd Newton's law	7
	Work and energy	8
	Heat and internal energy	9
	Electricity	15
	Magnetism	2
	Physics and the environment	2

Table 2. *The distribution of school hours for standard knowledge (SZ) and the experimental work (EV) according to the topics in the curriculum for Physics in gymnasium [6].*

Contents	*Number of school hours*		*Contents*	*Number of school hours*	
	SZ	*EV*		*SZ*	*EV*
Measurements, physics quantities and units	5	3	Electric current	4	2
Translational and rotational motion	7	3	Magnetic field	4	0
Force and torque	6	2	Induction	5	2
Newton's laws and gravity	5	2	Oscillations	5	4
Linear momentum*			Waves	7	4
Angular momentum*			Light	6	2
Work and energy	7	0	Atom	4	0
Liquids*			Semiconductors*		
Structure of matter and temperature	5	2	Atomic core	5	0
Internal energy and heat	7	2	Astronomy	3	0
Electric charge and electric field	4	0	*matura		



9 TOPLOTA IN NOTRANJA ENERGIJA	
Vsebinski sklop	**Operativni cilji**
9.1 Zgradba trdnin, kapljevin in plinov	Učenci: • analizirajo lastnosti snovi in gradnikov, iz katerih je zgrajena snov, • razložijo, da višja temperatura pomeni živahnejše gibanje gradnikov, • raziščejo lastnosti in razlike v zgradbi trdnin, kapljevin in plinov, • na mikroskopski ravni razložijo dogajanja ob taljenju, strjevanju, izparevanju in kondenzaciji snovi;
9.2 Temperatura	• opredelijo temperaturo kot količino, ki jo pokaže termometer, • spoznajo Celzijevo in Kelvinovo temperaturno lestvico in znajo pretvarjati zapise, • uporabijo termometer za merjenje temperature (E);
9.3 Temperaturno raztezanje	• raziščejo temperaturno raztezanje teles, • razložijo delovanje bimetala in razumejo njegovo uporabo;
9.4 *Tlak plina*	• *razložijo tlak plina,* • *razložijo medsebojno odvisnost tlaka, temperature in prostornine plina;*

9.2	**Segrevanje vode** Učenci nadgradijo operativno poznavanje temperature kot količine, ki jo izmerimo s termometrom s kvantitativno definicijo Celzijeve lestvice (tališče in vrelišče vode). Učitelj poudari povezavo med spreminjanjem temperature in prejemanjem ali oddajanjem toplote.

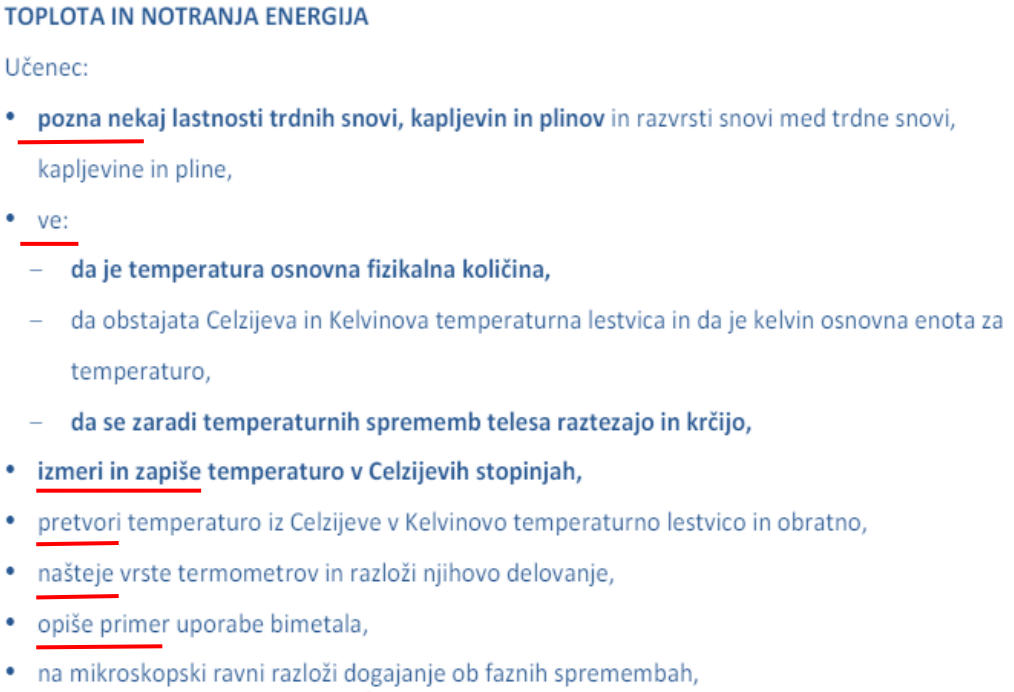
Figure 3. *Examples of learning objectives for the content Heat and internal energy from the primary school physics curriculum. Elective objectives are written in italics. Verbs expressing students' actions as analyse, explain, explore, describe, apply, compare, etc. are underlined. The elective subtopics or learning objectives are written in italics. If E is added, the experimental work is stressed and the description of the proposed experimental work is given as well [8].*

Comparison of external examination in physics at the end of the primary school and the gymnasium

Physics is not part of the national assessment of knowledge in the primary school every school year, but on 2 or 3 years, for example in 2008, 2012, 2014, 2016 and 2019. Physics exam is only written and it has 20 tasks with subtasks. It is recommended that during solving approximately half of the tasks students do not need calculators. Each subtask covers one learning objective from the curriculum. Students have 60 minutes to solve the exam. In 2019 the physics exam includes 20% of tasks covering the knowledge, 55% comprehension and application, and 25% problem solving, analysis, synthesis, evaluation [10].

On the other hand, physics is a part of the matura exam at the end of the gymnasium every year. However, in the school year 2017/2018 1412 students out of 6773 chose physics as a part of the matura exam in the spring term [11]. The matura exam in physics assess knowledge and skills and therefore takes into account the results of the researches about the importance of assessing skills [12,13]. Students carry experiments during the school year and prepare reports that are assessed by their teacher. The maximum of the

achieved points presents 20% of the possible points of the physics exam. However, 2 parts of the exam are written. Part 1, presenting 35% of the final mark, includes 35 multiple-choice questions and students have 90 minutes to solve it. In part 2, students receive the test with 6 structured tasks. However, they choose three for solving, the achievement of this part of the exam might present 45% of the final mark [7].



TOPLOTA IN NOTRANJA ENERGIJA

Učenec:

- **pozna nekaj lastnosti trdnih snovi, kapljevin in plinov** in razvrsti snovi med trdne snovi, kapljevine in pline,
- ve:
  - **da je temperatura osnovna fizikalna količina,**
  - da obstajata Celzijeva in Kelvinova temperaturna lestvica in da je kelvin osnovna enota za temperaturo,
  - **da se zaradi temperaturnih sprememb telesa raztezajo in krčijo,**
- **izmeri in zapiše temperaturo v Celzijevih stopinjah,**
- pretvori temperaturo iz Celzijeve v Kelvinovo temperaturno lestvico in obratno,
- našteje vrste termometrov in razloži njihovo delovanje,
- opiše primer uporabe bimetala,
- na mikroskopski ravni razloži dogajanje ob faznih spremembah,

Figure 4. *Examples of knowledge standards for the content Heat and internal energy from the primary school curriculum. The minimal standards are written in bold. It is very concretely written what student should know, measure, write, convert, list, describe, explain, etc. (underlined verbs) [8].*

Conclusion

In Slovenia both, the physics curriculum for primary and the physics curriculum for general secondary education (gymnasium) are very detailed documents enabling teachers to show what, how to teach and at the same time leaving them autonomy to choose some contents by their choice. On both levels, the external examination is held. However, in the gymnasium physics is an annual subject at the matura, if the student selects it. Physics at the end of the primary school is determined by the state as a part of a national assessment of knowledge per two or three years on one fifth of primary schools.

In the media is quite often said that curricula are too wide. Nevertheless, the discussions with authors of the curricula and teachers show that the reading and understanding of curricula might be an issue. It is true that the curricula development is an ongoing process taking into account the current professional knowledge, the findings of the latest research in the field of educational physics, teacher experiences, etc. However, despite the ongoing debates about the wideness and sometimes strictness of curricula, the professionals attempt to present the valid curricula, not as an obstacle but as an environment enabling also work based on the interest of students and teachers. It has to be reminded that experiments in different forms can certainly be suitable tools for increasing student interest in physics [14]

However, instead of the final paragraph. "*Curricula. In the matura classroom you practice a lot. However, science and technology are progressing with great strides and the number of science hours is not following. The teacher's dilemma, is it better to devote the time to the interpretation of contemporary, interesting topics, or is the time more efficiently used for a drill leading to better achievements in tests.*" [15]

10. Notranja energija in toplota (7 SZ in 2 EV)

Dijaki / dijakinje:

10.1 Znajo uporabiti energijski zakon in definirati toploto:
Dijaki zapišejo energijski zakon v obliki $A + Q = \Delta W_m + \Delta W_n$, kjer je A delo vseh zunanjih sil razen teže, W_n notranja in W_m mehanska energija. Izračunati znajo spremembo notranje energije zaradi dela trenja, upora in dovajanja toplote z grelcem.

V mikroskopski sliki enoatomnega plina kvalitativno razložijo notranjo energijo kot vsoto kinetičnih energij atomov ter toploto kot izmenjavo kinetične energije zaradi trkov med njimi.
[Medpredmetna povezava – fizika, kemija, biologija – različni vidiki energijskega zakona.]

10.2 Izpeljejo in uporabijo enačbo za delo tlaka.

10.3 Poznajo specifično toploto snovi in jo uporabljajo pri računanju:
Dijaki razložijo postopek merjenja specifične toplote z grelcem z znano močjo. Definicijo $c = Q/(m\Delta T)$ znajo uporabiti pri računih, v katerih nastopa ena snov.
[Medpredmetna povezava z geografijo – celinsko in obmorsko podnebje.]

10.4 Opišejo prehode med agregatnimi stanji:
Dijaki vedo, da ostane temperatura med faznim prehodom nespremenjena in to kvalitativno pojasnijo v mikroskopski sliki. Ločijo med taljenjem, strjevanjem, izparevanjem in kondenzacijo. Vedo, da je temperatura faznega prehoda specifična za snov in odvisna od tlaka. Pojasnijo prejemanje ali oddajanje toplote med faznim prehodom.

Figure 5. *Examples of learning objectives for the content Heat and internal energy from the gymnasium curriculum. General knowledge objectives are written normally, specific knowledge in italics, both in bold. Underlined verbs define what students know, define, apply, describe, etc. Concrete expected outcomes are written under the learning objective. Learning objectives, covering elective contents, are on the grey background. Cross-curricular integration options are on the red background. [6].*

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