Analyzing the Relevance of Learning Outcomes associated with the Concept of Energy in Estonian (Grade 7-9th) Science) Curriculum

10th European Variety in University Education 2023 (June 28-June 30)
Estonia, Tartu, Chemicum

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30.06.2023

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Tartu University Chemistry Institute
2nd Year PhD Student
Curriculum: Educational Science

Funded by the Horizon 2020 Framework Programme of the European Union

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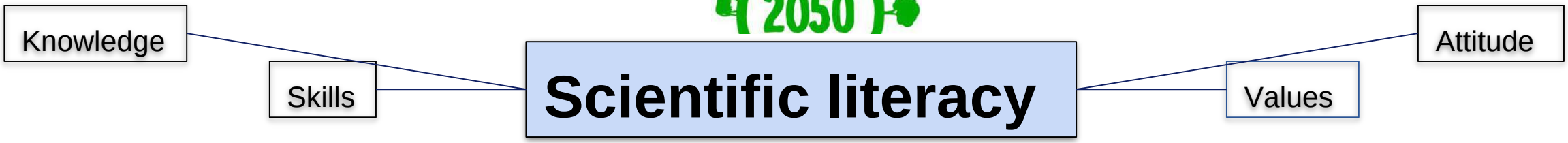
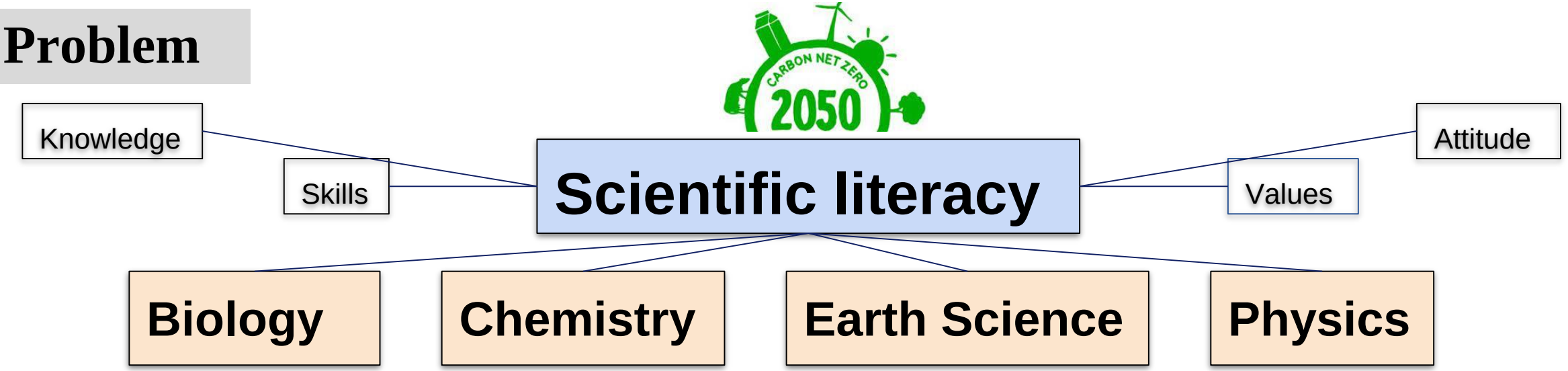
keemia instituut

Problem

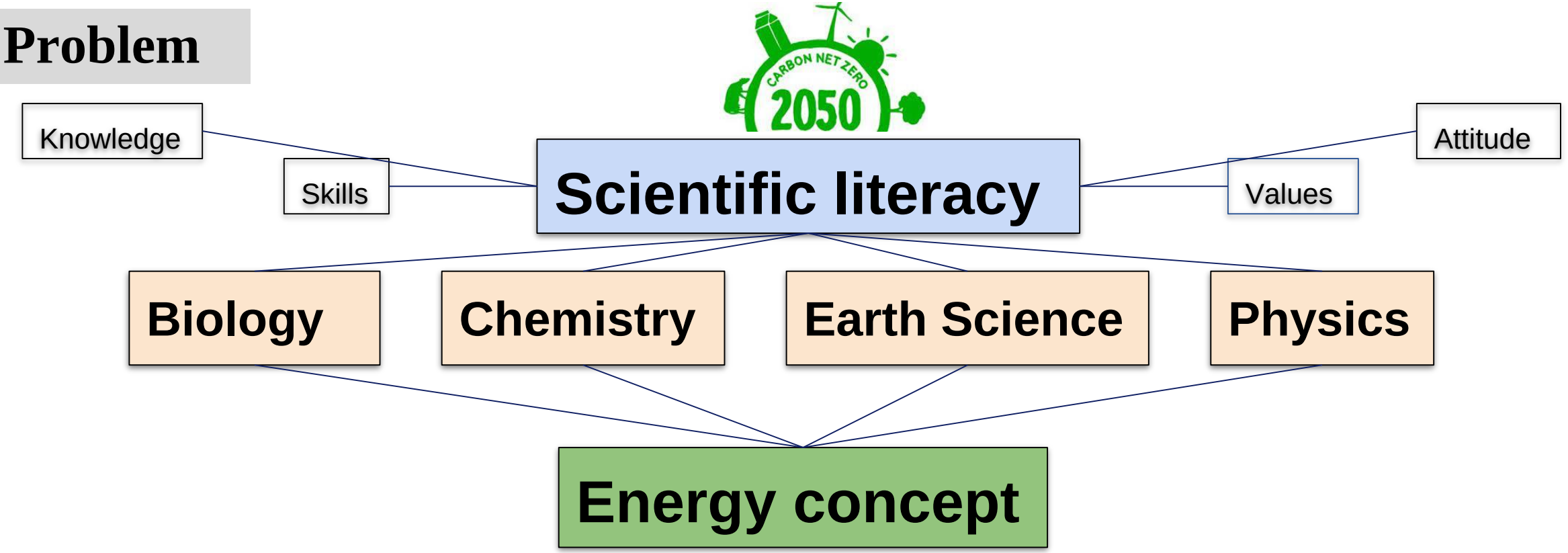
Problem



Problem


CARBON NET ZERO
2050
Knowledge
Skills
Scientific literacy
Attitude
Values
Biology
Chemistry
Earth Science
Physics

Problem


CARBON NET ZERO
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Knowledge
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Biology
Chemistry
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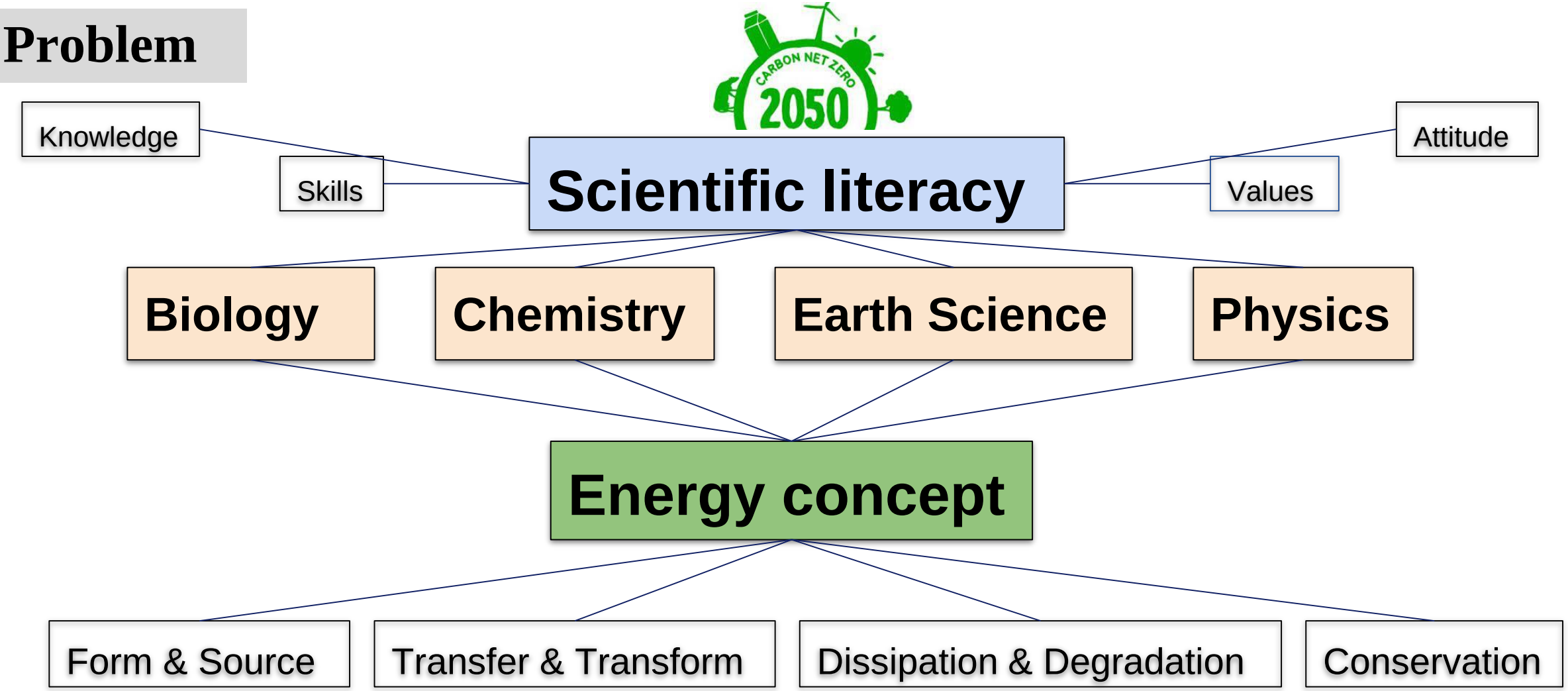
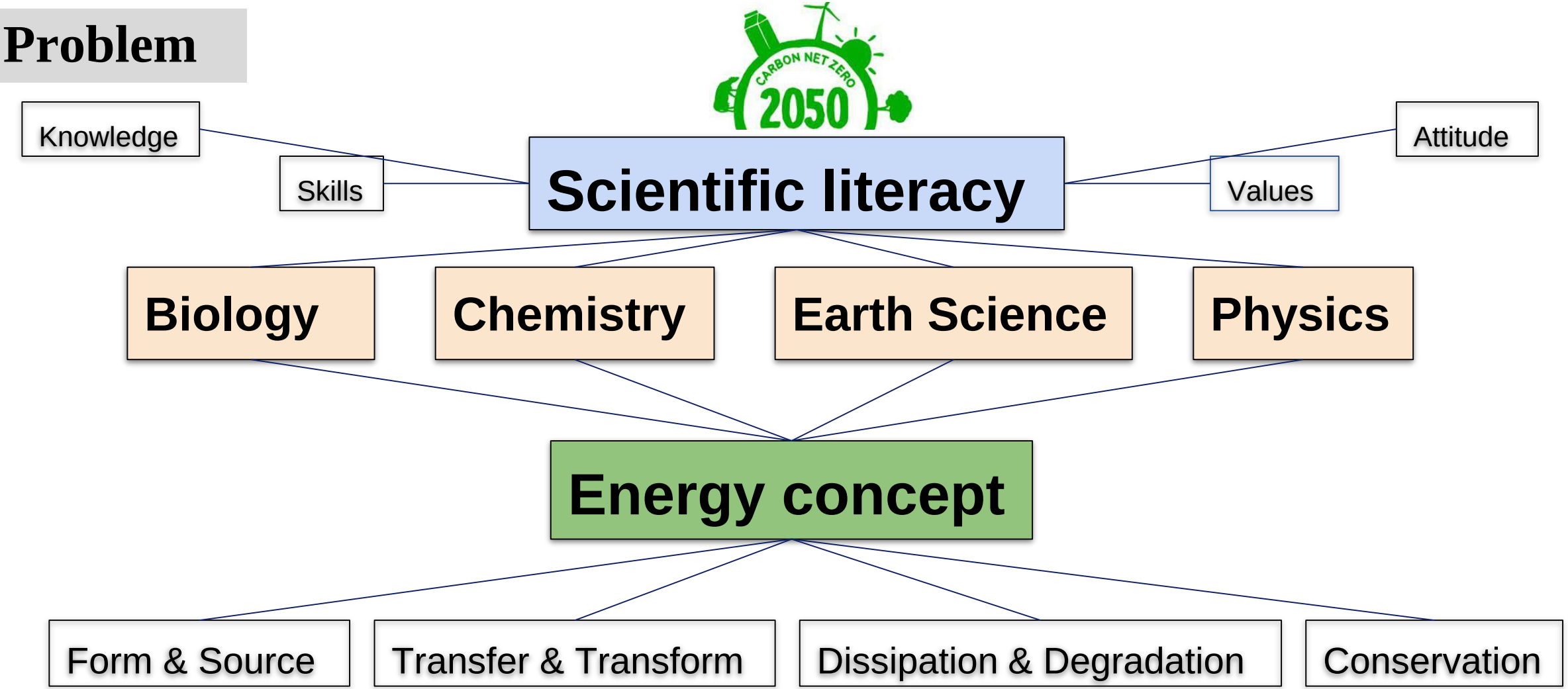
Physics
Energy concept

Problem


Knowledge
Skills
Scientific literacy
Attitude
Values
Biology
Chemistry
Earth Science
Physics
Energy concept
Form & Source
Transfer & Transform
Dissipation & Degradation
Conservation

Problem



Students have **problems** understanding the energy concept (Ben-Zvi et al., 1993; Driver et al., 2014; Herrmann-Abell & DeBoer, 2018; Mamlok-Naaman & Mandler, 2020). Cooper and Klymkovsky (2013), and Dreyfus et al. (2012) indicate that the **fragmentation** of the energy concept **between science subjects** leads to the possibility that students obtain an **incomplete understanding** of the **energy concept** as a whole.

PhD research design

Intended curriculum
(Using quant + qual with document analysis method)

1st article - submitted

PhD research design

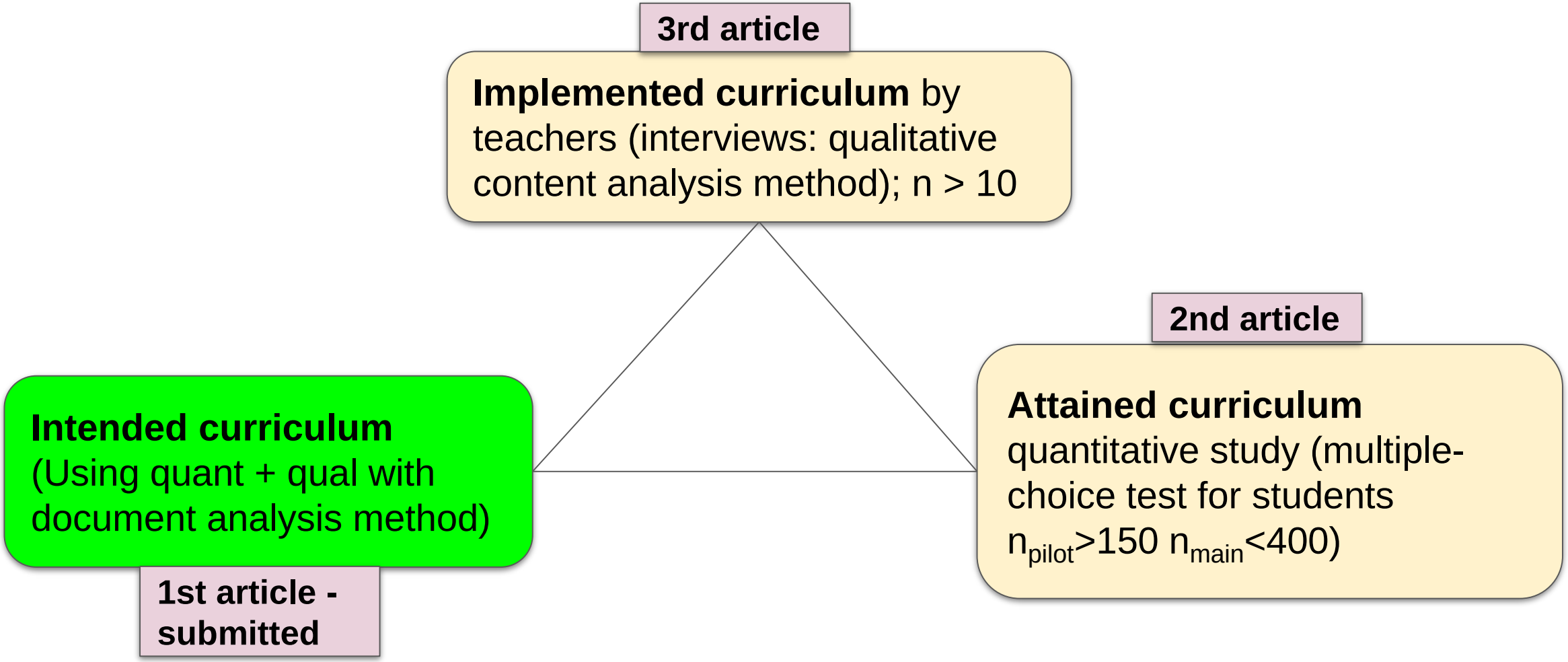
Intended curriculum
(Using quant + qual with document analysis method)

1st article - submitted

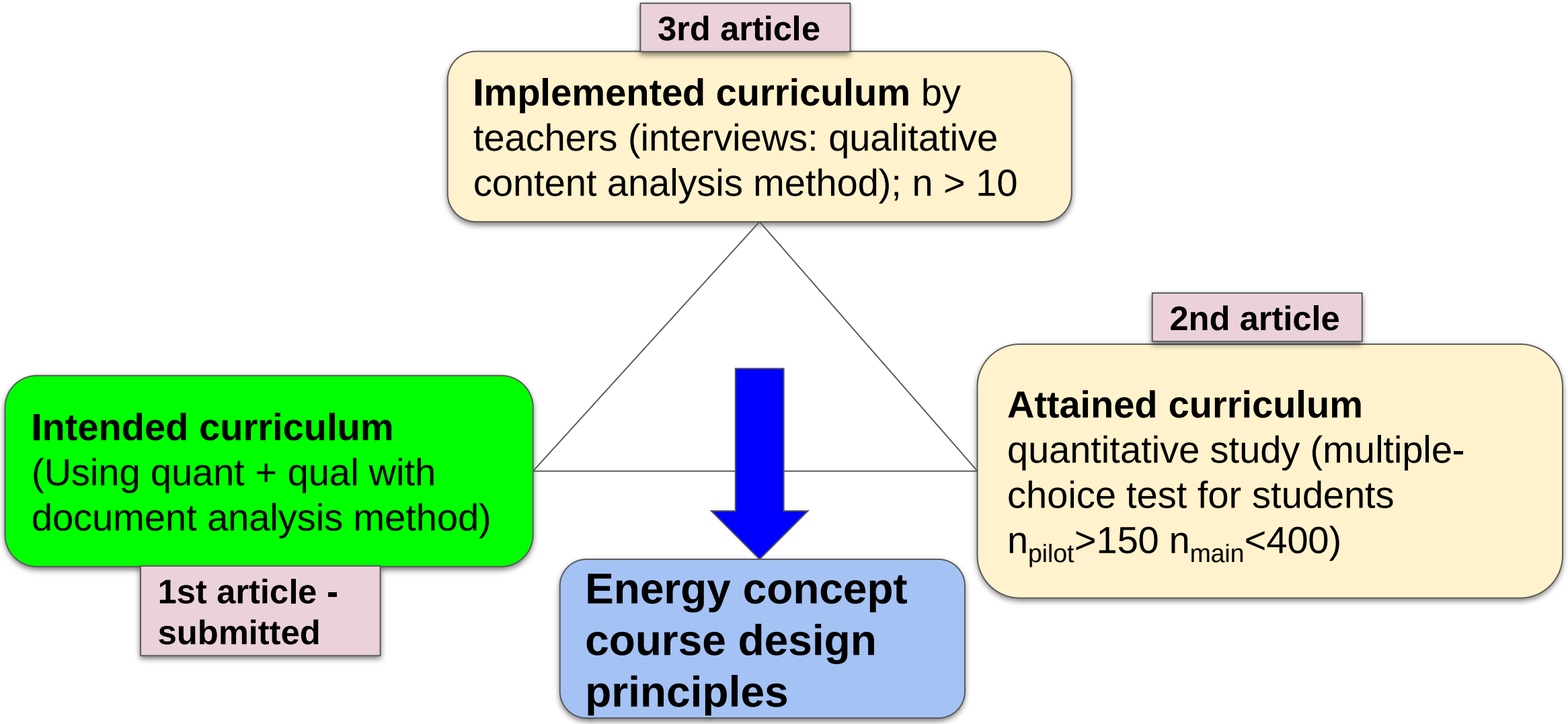
2nd article

Attained curriculum
quantitative study (multiple-choice test for students n_{pilot}>150 n_{main}<400)

PhD research design



PhD research design



Learning Outcome focus on Estonian National 7-9th grade Science Curriculum

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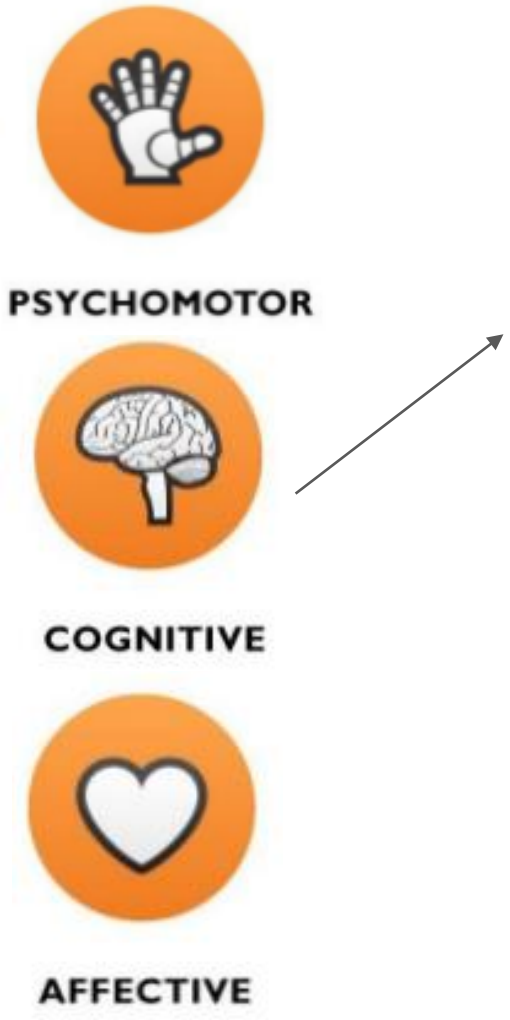
1) LEARNING DOMAIN



Learning Outcome focus on Estonian National 7-9th grade Science Curriculum

1) LEARNING DOMAIN

PSYCHOMOTOR

COGNITIVE

AFFECTIVE

SOLO taxonomy

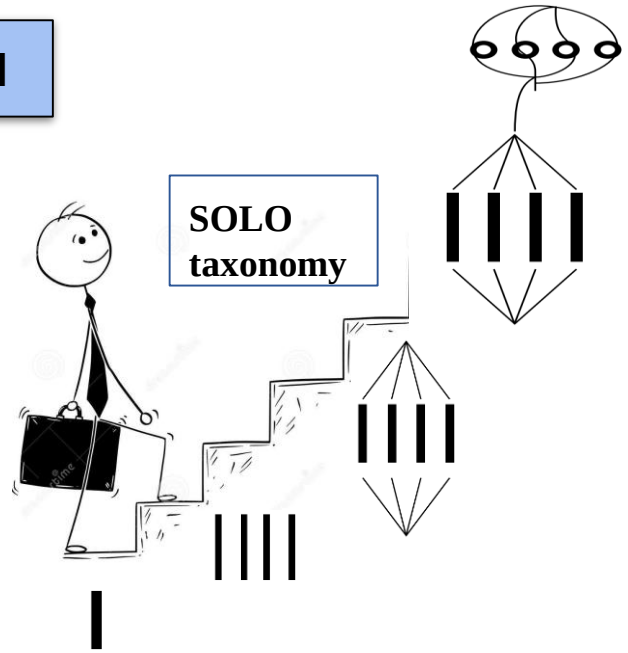
Learning Outcome focus on Estonian National 7-9th grade Science Curriculum

1) LEARNING DOMAIN

PSYCHOMOTOR

COGNITIVE

AFFECTIVE



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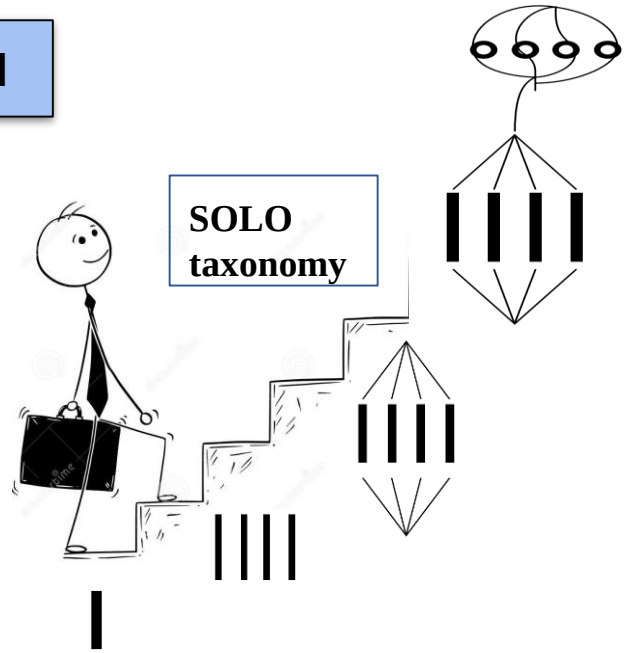
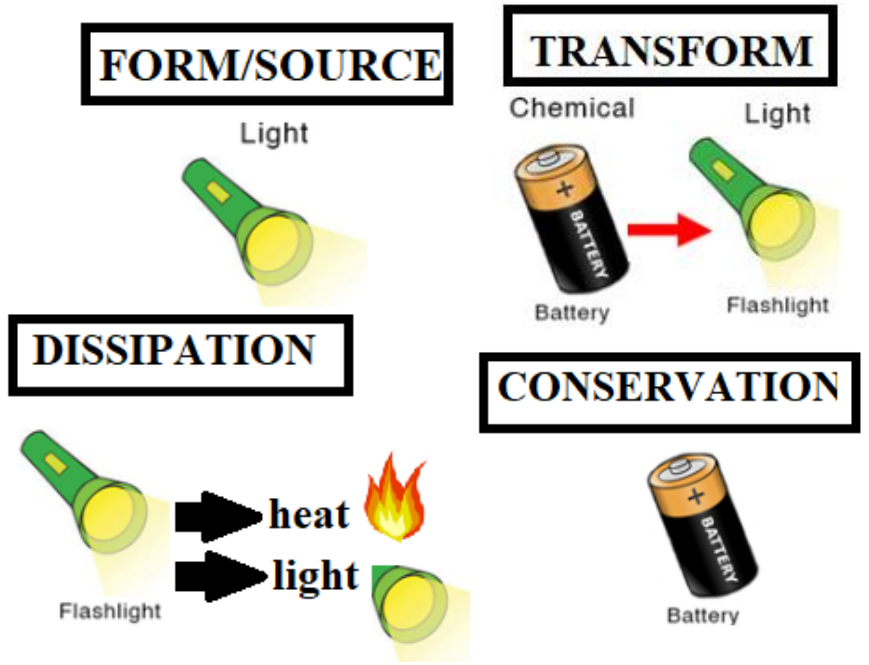


2) ENERGY CONCEPT



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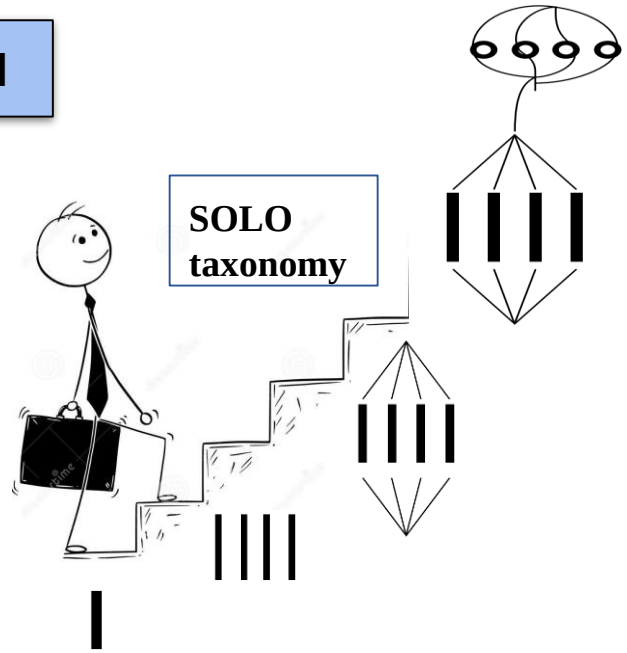


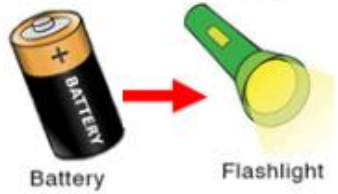
2) ENERGY CONCEPT

FORM/SOURCE

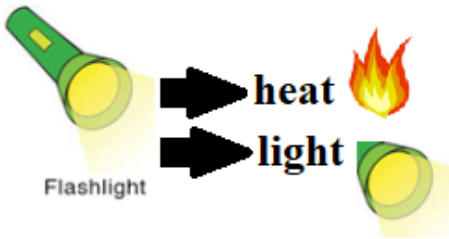
Light

TRANSFORM

Chemical Light

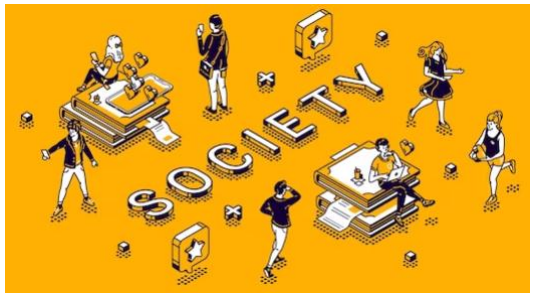


DISSIPATION



CONSERVATION

3) SCIENCE EDUCATION RELEVANCE



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Text size: A A A

National curriculum for basic schools

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Translation | Authentic text

Issuer: Government
Type: regulation
In force from: 17.01.2011
In force until: 22.09.2011
Translation published: 24.09.2014

Parallel texts

National curriculum for basic schools

Passed 06.01.2011 No. 1

The regulation is established on the basis of Subsection 15 (2) of the Basic Schools and Upper Secondary Schools Act.

Chapter 1
GENERAL PROVISIONS

§ 1. Scope of application and structure of regulation

The national curriculum for basic schools establishes the national standard for basic education.
The national curriculum for basic schools (hereinafter *national curriculum*) shall be applied in all basic schools in the Republic of Estonia regardless of the

§ 26. Repeal of regulation

Regulation No 14 of the Government of the Republic of 28 January 2010, "National curriculum for basic schools" (RT I 28.12.2010, 17) is hereby repealed.

Andrus Ansip
Prime Minister

Hanno Pevkur
Minister of Social Affairs, Acting as Minister of Education and Research

Heiki Loot
Secretary of State

Annex 1
Annex 2
Annex 3
Annex 4

Appendix 4
of Regulation No. 1 of the Government
of the Republic of 6 January 2011
National Curriculum for Basic Schools

Last amendment 29 August 2014

Subject Field: Natural Science

1. General Principles
1.1. Competence in Natural Science

The gaining of competencies in natural science refers to the capability to: observe and explain phenomena and processes that exist in the natural, technological and social environment (hereafter referred to as 'the environment'); analyse the environment as a system; identify science-related problems occurring in the

2.2.4. Learning Outcomes and Learning Content of Biology in the 3st stage of study
2.2.4.1. Biology as a Field of Study Area of research in Biology Research area in Biology? Learning Outcomes

The students:

1) explain the connection of biology studies to other sciences and everyday life as well as the development of technology; **(Understand B2,S2)**
2) analyse the necessity of biology-related knowledge and skills in different professions;
3) compare the external characteristics of animals, plants, mushrooms, protozoa and bacteria; **(Analyze B4)**
4) divide organisms according to pictures and descriptions into animals, plants and mushrooms; **(Apply B3)**
5) associate forms of life with different groups of organisms; **(Analyze B4,S3)**
6) make wet preparations and use a light microscope to study them; and
7) value scientific methods when drawing trustworthy conclusions.

Learning Content

Content of biology and relation to other natural sciences and role in developing contemporary technologies. Main research methods of biology: observations and experiments. Stages and application of scientific method. Division of organisms into animals, plants, mushrooms, protozoa and bacteria and comparison of their external characteristics. Forms of life of representatives of different groups of organisms.

Concepts: biology, organism, observation, experiment

Practical work and use of ICT

1. Preparing a wet preparation and comparing different objects with a microscope.
2. Comparing the external characteristics of different groups of organisms on the basis of real objects or information acquired from the Internet. (First part is cognitive and tool is internet - long story short - Shit)

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Method (Document analysis)

- Learning outcome + Practical Work and ICT
- **Verb,** read the **context** and **classify**

associate forms of life with different groups of organisms; **(Cog: Analyze - S3)**
make wet preparations and use a light microscope to study them; and **(P.M.)**
value scientific methods when drawing trustworthy conclusions. **(Aff.)**

- List of nouns and 1 verb = 1 LO *(Learning outcome)*

explain the meaning of focal length and optical lens strength **(Understand - S2)**

- 2 verbs and 1 noun = 2 LO

describe and analyse the main properties of some of the most important inorganic compounds**(Understand - S2)(Analyze - S3)**

Validity and reliability

- Expert validation for the method
- Coding 3 times (with 2 months interval)
- Using 4th time active teacher as a outside coder
- The outside coder results were not considered as agreement if we had agreement between all 4 categories
  - learning domain,
  - SOLO taxonomy level
  - energy concept component
  - relevance dimension.

Later, inter-rater agreement percentages between coders were calculated. Summative reliability value was **.88** (interdisciplinary science = .75; biology = .86; earth science = .89; physics= .93; chemistry = .95).

Results I - LO distribution based on learning domain

Learning domain		Science curriculum LO distribution						Energy concept LO distribution					
		I.S.*	Bio.*	E.S.*	Phy.*	Che.*	Tot.*	I.S.	Bio.	E.S.	Phy.	Che.	Tot.
Cognitive	LO number	32	158	137	142	105	574	13	26	47	95	27	208
Psychomotor	LO number	35	12	41	39	49	176	20	1	7	18	16	62
Affective	LO number	2	23	5	-	2	32	-	-	3	-	1	4
Amount of LO per subject		69	193	183	181	156	**782**	33	27	57	113	44	**274**
No. of science lessons on 7-9th grade		70	175	175	140	140							
Average number of LOs per lesson		1.0	1.1	1.0	1.3	1.1							

Note. I.S. = interdisciplinary science; Bio. = biology; E.S. = earth science; Phy. = physics ; Che. = chemistry: Tot. = total

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2:1 ratio

35 %

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Results II - cognitive LO distribution

Learning domain		Curriculum cognitive LO distribution						Energy concept LO distribution					
		I.S.	Bio.	E.S.	Phy.	Che.	Tot.	I.S.	Bio.	E.S.	Phy.	Che.	Tot.
Unistructural	LO number	3	**1**	8	14	7	33	-	-	5	7	1	13
Multistructural	LO number	10	43	55	82	35	**225**	3	1	21	56	11	**92**
Relational	LO number	11	107	63	38	57	**276**	7	24	14	26	11	**82**
Extended abstract	LO number	8	7	11	8	6	40	3	1	7	6	4	21
Number of subject LOs		32	158	137	142	105	574	13	26	47	95	27	208

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Results II - cognitive LO distribution

Lower vs higher = 44,9% to 55.1%

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Results III - Energy Concept Learning Outcomes distribution

Subject	Four energy categories														
	E_1*	E_2*	E_3*	E_4*	$E_{1,2}$	$E_{1,3}$	$E_{1,4}$	$E_{2,3}$	$E_{2,4}$	$E_{3,4}$	$E_{1,2,3}$	$E_{1,2,4}$	$E_{1,3,4}$	$E_{2,3,4}$	$E_{1,2,3,4}$
Interdisciplinary science	4	16	1	10	2	-	-	-	-	-	-	-	-	-	-
Biology	-	22	-	-	-	-	-	2	-	-	-	-	-	3	-
Earth Science	12	24	4	3	4	-	-	1	1	2	-	-	-	-	6
Physics	10	51	3	-	15	-	-	10	-	-	9	-	3	1	11
Chemistry	7	10	1	1	11	-	-	3	2	1	-	6	-	-	2
Total	33	**123**	9	14	**32**	-	-	16	3	3	**9**	**6**	**3**	4	19

Note. E_1=Energy source/form; E_2=Energy transfer/transformation; E_3=Energy degradation/dissipation, E_4=Energy conservation

Results III - Energy Concept Learning Outcomes distribution

Subject	Four energy categories														
	E_1*	E_2*	E_3*	E_4*	$E_{1,2}$	$E_{1,3}$	$E_{1,4}$	$E_{2,3}$	$E_{2,4}$	$E_{3,4}$	$E_{1,2,3}$	$E_{1,2,4}$	$E_{1,3,4}$	$E_{2,3,4}$	$E_{1,2,3,4}$
Interdisciplinary science	4	16	1	10	2	-	-	-	-	-	-	-	-	-	-
Biology	-	22	-	-	-	-	-	2	-	-	-	-	-	3	-
Earth Science	12	24	4	3	4	-	-	1	1	2	-	-	-	-	6
Physics	10	51	3	-	15	-	-	10	-	-	9	-	3	1	11
Chemistry	7	10	1	1	11	-	-	3	2	1	-	6	-	-	2
Total	33	**123**	9	14	**32**	-	-	16	3	3	**9**	**6**	**3**	4	19

63%

Note. E_1=Energy source/form; E_2=Energy transfer/transformation; E_3=Energy degradation/dissipation, E_4=Energy conservation

Results IV - Science Education Relevance

Subject	Curriculum LO relevance distribution							Energy concept LO relevance distribution						
	R_1^*	R_2^*	R_3^*	$R_{1,2}$	$R_{1,3}$	$R_{2,3}$	$R_{1,2,3}$	R_1	R_2	R_3	$R_{1,2}$	$R_{1,3}$	$R_{2,3}$	$R_{1,2,3}$
interdisciplinary Science	46	1	-	13	-	-	9	15	1	.	9	-	-	8
Biology	152	30	3	6	-	2	-	24	2	.	-	1	-	-
Earth Science	123	41	4	9	-	4	2	23	23	2	6	-	2	1
Physics	166	3	1	11	-	-	-	91	12	1	9	-	-	-
Chemistry	123	16	-	3	-	6	7	24	13	-	1	-	3	3
Total	610	91	**8**	42	**1**	**12**	**18**	177	51	**3**	25	**1**	**5**	**12**

Note. R_1 = Individual dimension; R_2 = Societal dimension; R_3 = Career dimension

Results IV - Science Education Relevance

Subject	Curriculum LO relevance distribution							Energy concept LO relevance distribution						
	R_1*	R_2*	R_3*	$R_{1,2}$	$R_{1,3}$	$R_{2,3}$	$R_{1,2,3}$	R_1	R_2	R_3	$R_{1,2}$	$R_{1,3}$	$R_{2,3}$	$R_{1,2,3}$
interdisciplinary Science	46	1	-	13	-	-	9	15	1	.	9	-	-	8
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5%

Conclusions & Implications

- LOs are **mainly** in **cognitive** domain (**~ ¾**)
- **Lack of affective** domain in LOs (**4%**)

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- **2:1** ratio between **cognitive** and **psychomotor** domain in **chemistry**

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- **2:1** ratio between **cognitive** and **psychomotor** domain in **chemistry**
- **Energy** is **important concept** in science education (~ ⅓)

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- **2:1** ratio between **cognitive** and **psychomotor** domain in **chemistry**
- **Energy** is **important concept** in science education (~ ⅓)
- **Low vs high** cognitive LOs have ~ **1:1** distribution
- Analysing **method can be used** for **other disciplines** (e.g. grammar in languages etc)

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- **2:1** ratio between **cognitive** and **psychomotor** domain in **chemistry**
- **Energy** is **important concept** in science education (~ **⅓**)
- **Low vs high** cognitive LOs have ~ **1:1** distribution
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- **Energy transfer-transform** LO are covering (~ **⅔**)
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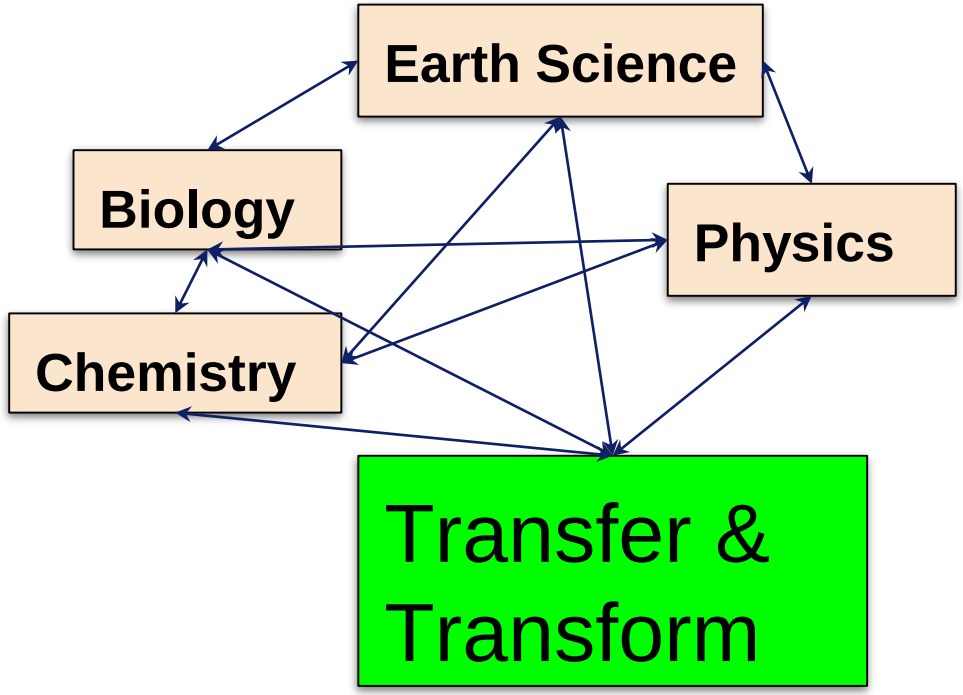

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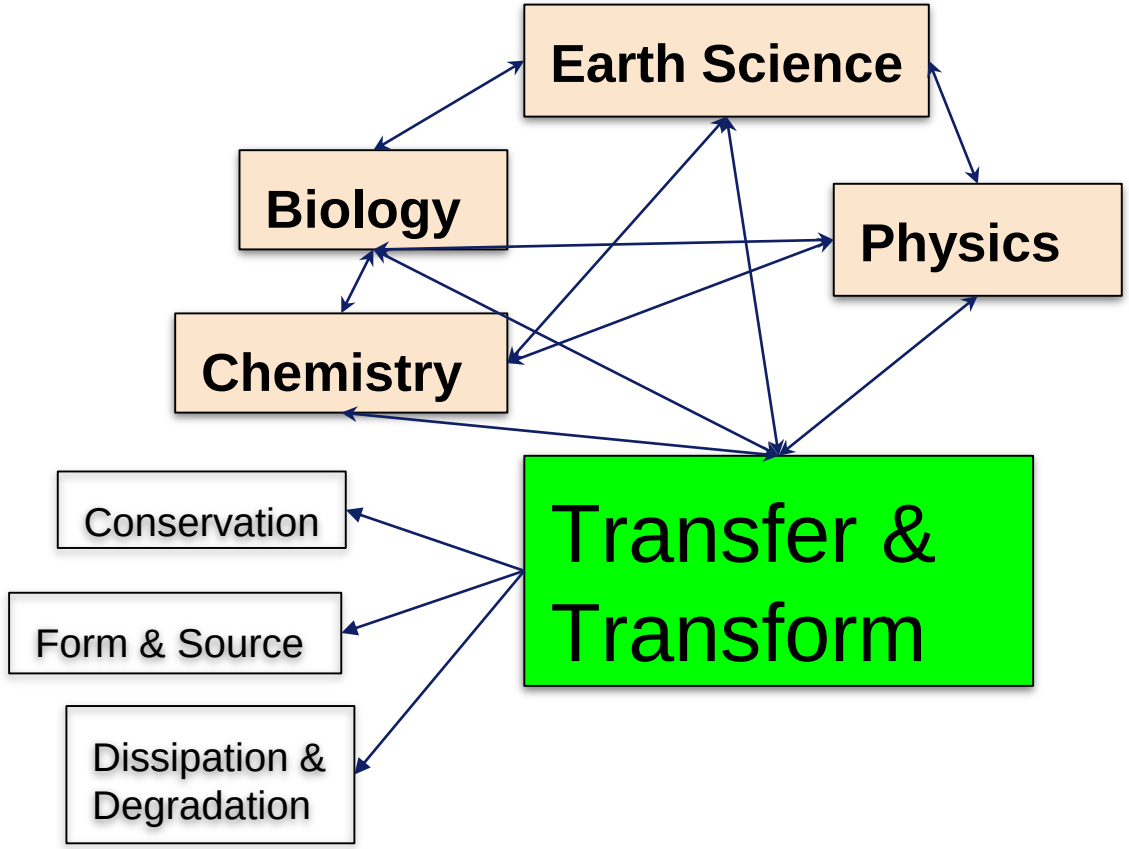

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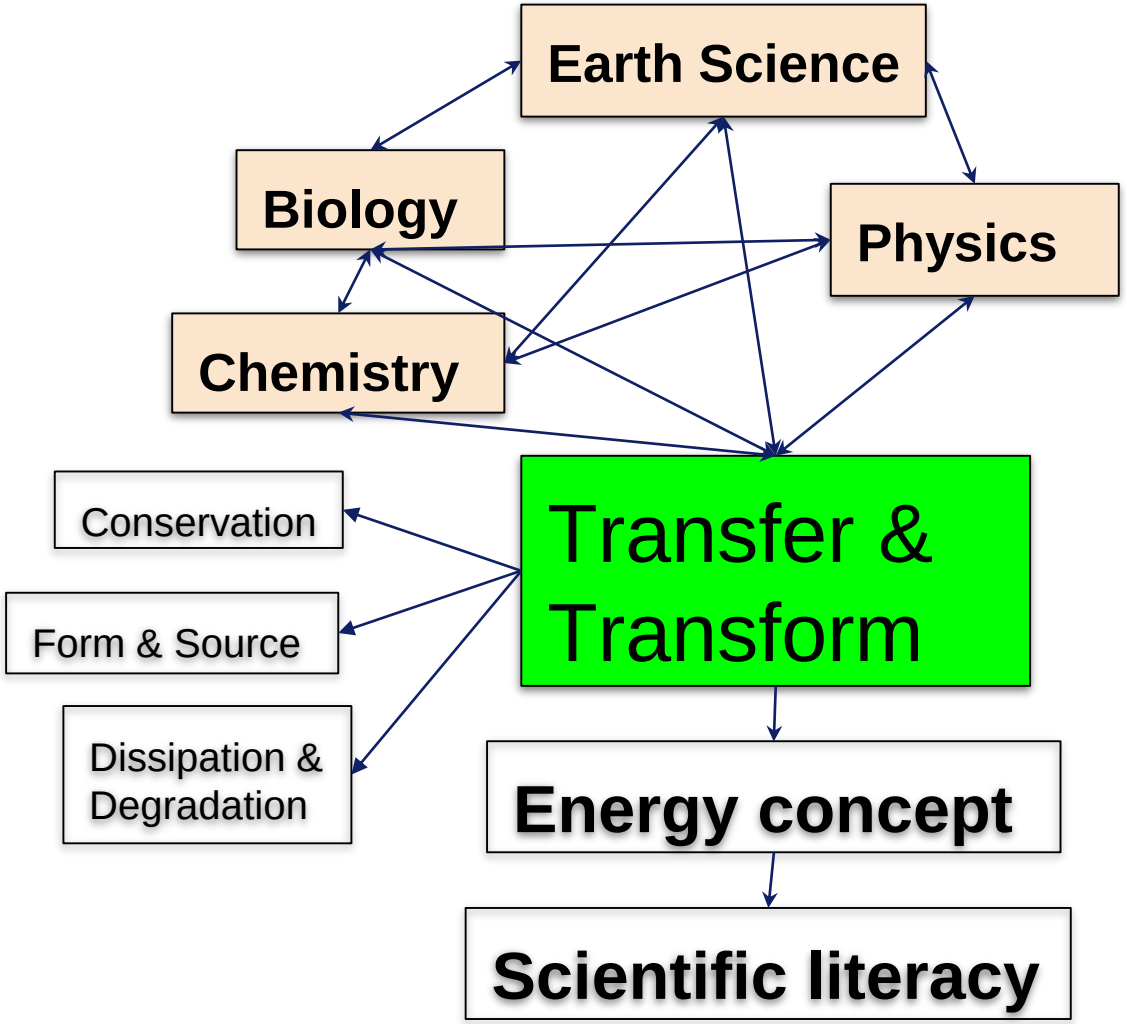

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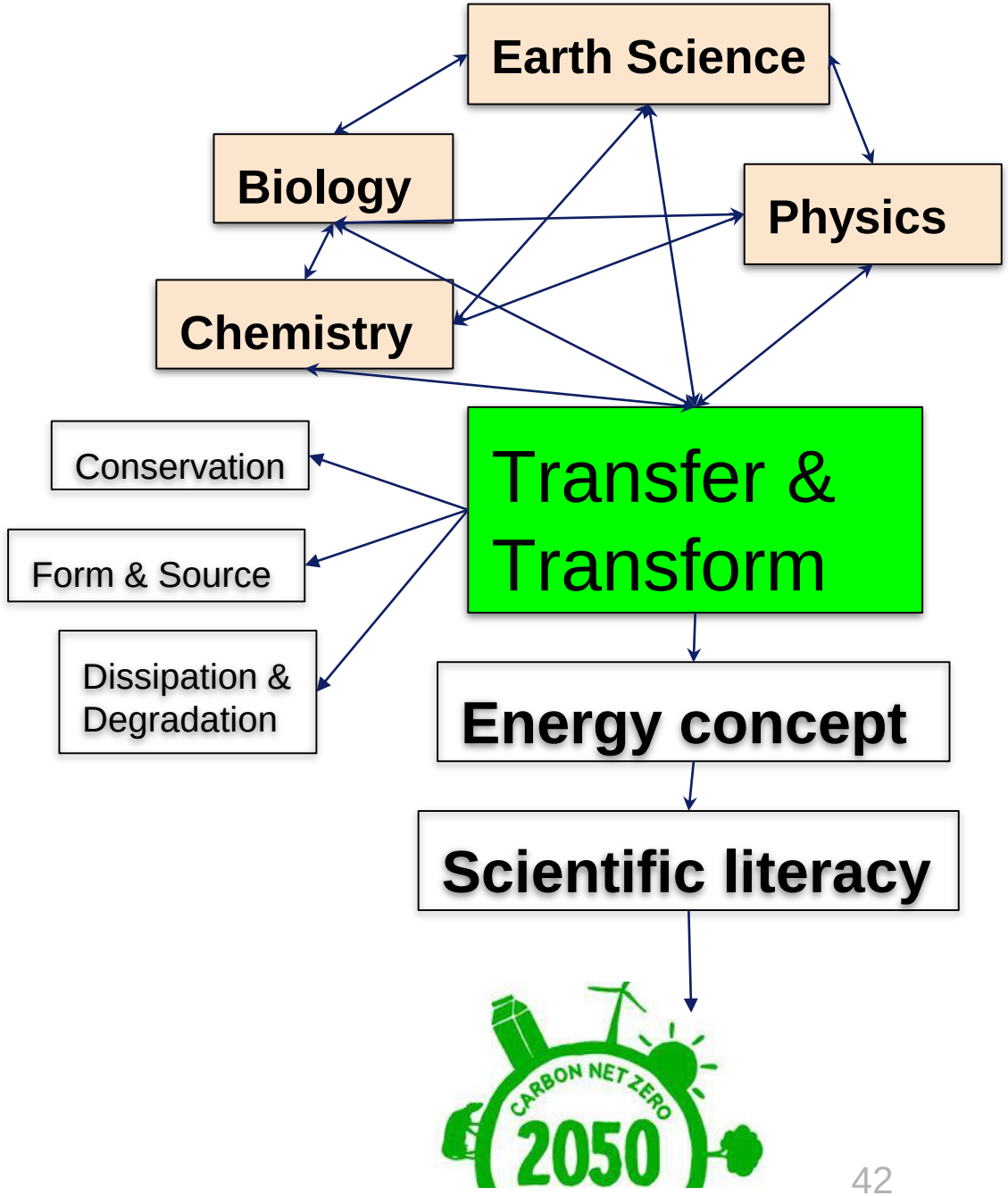

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Thank you for listening!

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