

SIXTH FRAMEWORK PROGRAMME

## PRIORITY 2: Information Society Technologies

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### Skill Structure Specification for the Advanced Framework

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## 1 Scope of this document

This document provides a specification of the skills involved in the advanced framework, the prerequisite relation between them, and the resulting skill structure. In addition, the document describes how the skills, the prerequisite relation between them, and the resulting skill structure have been obtained. Finally, this document provides the mapping of skills/skill states to LeS 1.1.3, 1.2.1, 1.3.1, and 1.3.3. These data provide the basis for the intermediate framework ontology (version VIII).

## 2 Skills and skill structures in the intermediate demonstrator

### 2.1 Original version

The original version of the skill list involved in the intermediate demonstrator and the related prerequisite relation between these skills and the resulting skill structure is based on the skill list and skill structure introduced in the M12 report. These documents have been revised according to the requirements of LeS 1.2.1, 1.2.3, 1.3.1, and 1.3.3. The result was a list of 83 skills (Table 1) and a corresponding prerequisite relation (Figure 1).

Table 1. *Original list of skills.*

Nr.	Symbol	Abbreviation	Description
1	o04	Object may emit light	Knowledge that certain objects (such as lamps or stars) can emit light
2	m03	Angle	Knowledge of what an angle is.
3	m04	Perspective	Knowledge about the relation of different viewpoint, e.g. front view versus top view of the same object.
4	o02	Ray of light	Knowledge to define a ray of light
5	o05	Objects may block light	Knowledge that certain objects (such as walls or panels) can block light
6	c01	Abstraction	Being able to abstract concepts (e.g., reducing a 3D model to a 2D model) on a basic level.
7	t01	Light sensor	Knowledge of what a light sensor is.
8	t02a	Flashlight emits light	Knowledge of what a flashlight is and that it emits light
9	t02b	Spotlight emits light	Knowledge of what a spotlight is and that it emits light
10	o06	Reflection of light	Basic comprehension that light can be reflected on surfaces and knowledge about the basic rules and knowledge that certain objects (such as mirrors or stones) can reflect light

11	o01	Beam of light	Knowledge to define a beam of light
12	o04a	Amount of light varies	Knowledge that the amount or intensity of light emitted by different objects may vary
13	o07	Irregular reflection	Being able to apply irregular reflection <sup>1</sup> of light to surfaces
14	o07a	Reflected light is visible	Knowledge that light must be reflected by an object to be visible
15	o03	Straight propagation	Knowledge that light propagates in straight lines and that light is not affected by gravity or other external forces (such as wind or magnetic force).
16	o08	Shadow	Knowledge that objects blocking light are causing shadow.
17	t03	Screen reflects light	Knowledge of what a screen is and that it makes la beam of light visible by reflecting it.
18	m01	2D modeling	Being able to draw and manipulate 2D representations of physical settings and events.
19	a01	Star	Knowledge of what a star is.
20	o05a	Blind	Knowledge of what a blind is (regulation of the amount of incoming light), including knowledge that a smaller hole produces a narrower beam of light.
21	o09	Core shadow	Knowledge of what core shadow is.
22	m02	Homotheties	Comprehension of estimating homothety of a center point and the ratio of distances in a triangle.
23	o12	Position of object matters	Comprehension that the position of light emitting and light blocking objects are influencing the size of the shadow.
24	o13	Size of blocking object matters	Comprehension that the size of the light blocking object is influencing the size of the shadow.
25	o14	Size of emitting object matters	Comprehension that the size of the light emitting object is influencing the size of the shadow.
26	o05b	Apply blinds	Being able to apply the blinds concept to narrow a beam of light.
27	o11	Shape estimation (1)	Comprehension that the shape of an object blocking light influences the shape of the shadow and ability to estimate the shape of a shadow depending on the shape of the blocking object.
28	o10	Semi-shadow	Knowledge of what semi-shadow is.

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<sup>1</sup> In regular reflection rays are reflected in parallel (a mirror reflects light regularly and thus, a mirror image is discernible). In contrast irregular reflections appear in random directions (a piece of paper reflects light irregularly and thus, a white area is visible).

29	a02	Planet	Knowledge of what a planet is.
30	o15	Size estimation	Being able to estimate the size of a shadow in a certain setting <sup>1</sup> by using homotheties and being able to describe the size by 2D modelling.
31	a04	Space	Knowledge of space.
32	a03	Satellite	Knowledge of what a satellite is.
33	a05	Celestial body	Knowledge that planets, satellites, and stars are objects moving through space establishing the universe. These objects are called Celestial Bodies.
34	a07	Moon = satellite	Knowledge that the moon is a satellite.
35	a06	Earth = planet	Knowledge that earth is a planet.
36	a08	Sun = star	Knowledge that sun is a star.
37	o16	Shape estimation (2)	Comprehension that the shape of the screen the shadow is falling on influences the shape and the size of the shadow and being able to roughly estimate the shape and size of a shadow on a screen that is not plane.
38	o17	Motion estimation	Comprehension that the motion of the light emitting and blocking objects is influencing the size, shape, and position of the shadow and being able to estimate the motion of the shadow depending on a certain setting (size, distance) and the motion of objects.
39	a09	Orbit	Knowledge that celestial bodies in the universe moving on specific trajectories around each other.
40	a10	Orbit of planet	Knowledge that a planet surrounds a star on a specific trajectory.
41	a11	Orbit of satellite	Knowledge that a satellite surrounds a planet on a specific trajectory.
42	a15	Solar system	Knowledge that a solar system consists of a star or a double star, one or more planets, and possibly satellites orbiting around planets.
43	a12	Orbital plane	Knowledge that orbits are on specific planes which have a certain angle to the surrounded object and that this angles constantly changes.
44	a16	More planets in our solar system	Knowledge that there are 8 known planets in our solar system.
45	a13	Planets are on different orbital planes	Knowledge that the planets surround a star are on different orbital planes.

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<sup>1</sup> Meaning the shadow of a given object lighted by one given light spot.

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46	a14	Satellites are on different orbital planes as their planets	Knowledge that satellites and planets are moving on orbital planes which are generally not the same.
47	a17	More satellites at planets in our solar system	Knowledge that other planets in our solar system have satellites and that some planets have more than one satellite
48	a18	Other planets	Knowledge of the existence of other planets of our solar system and their names
49	a20a	Moon is not on the same orbital plane as earth	Being able to apply the knowledge about orbital plane to earth and moon (including knowledge that moon is not on the same orbital plane as earth).
50	a21	Eclipse	Knowledge that when the orbits of three celestial bodies, among them one star, are on the same plane one celestial body blocks the light of the star and causes a shadow of a specific size and in a specific region of the other one.
51	a19	Order of planets	Knowledge of the order of planets in our solar system.
52	a20	Callisto	Knowledge that Callisto is one of Jupiter's satellites.
53	a22	Shape of eclipse	Knowledge that the shape of an eclipse is circular due to the shape of celestial bodies.
54	a23	Partial eclipse	Knowledge that one celestial body may block only parts of the star's light causing a partial eclipse.
55	a24	Total eclipse	Knowledge that one celestial body may block the complete light from a star causing a total eclipse.
56	a26	Solar eclipse	Knowledge that a solar eclipse occurs when the moon moves between sun and earth.
57	a25	Lunar eclipse	Knowledge that a lunar eclipse occurs when earth moves between sun and moon.
58	a27	Callisto eclipse	Knowledge that a Callisto eclipse occurs when the satellite Callisto moves between sun and Jupiter.
59	a28	Manipulate eclipse scenarios	Being able to understand, create, or estimate different scenarios of eclipses in 2D and 3D representations.
60	c02	2D Repres.	Being able to understand simple 2D representations.
61	p10	Trajectory	Knowledge of what a trajectory is, influenced by gravity.
62	p01	Gravity	Basic knowledge about gravity (makes objects fall to the ground).
63	p09	External forces	Knowledge that wind and magnetic forces are external forces and may counter gravitation forces to a certain extent. Knowledge that this counter force influences the trajectory of objects.

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64	p06	Metal	Knowledge of what metal is.
65	p04	Magnet	Knowledge of what a magnet is and that it affects only metals.
66	p05a	Iron	Knowledge that iron is a metal, which is affected by a magnet.
67	p05b	Wood	Knowledge that wood is not a metal.
68	p05c	Plastic	Knowledge that plastic is not a metal.
69	p03	Weight	Knowledge of what weight means and that different materials have different weights. This skill includes the knowledge that iron has more weight than wood and, in turn, wood has more weight than plastic.
70	p07a	Solid	Understanding of what solid means.
71	p07b	Hollow	Understanding of what hollow means and that hollow objects of a specific material have less weight than a solid object of the same material.
72	P11	Slope device	Being able to apply knowledge about materials, magnetic force, wind, and gravity to influence the trajectories of objects.
73	o18	Laser	Knowledge that a laser emits a narrow beam of light.
74	o05c	Blind-X	Procedural knowledge about the effects on the beam of light when moving a blind along the x axis (closer or farther from the screen or light source).
75	o05d	Blind-Y	Procedural knowledge about the effects on the beam of light when moving a blind along the y axis (to the left or the right of the screen or light source).
76	o05e	Blind-Z	Procedural knowledge about the effects on the beam of light when moving a blind along the z axis (up and down in comparison to screen or light source).
77	m05	Distance	Understand the impact of distance on the effects of a 2D representation (e.g., the one of a blind).
78	c03	Transfer	Being able to transfer the principles of a concept from one situation to another.
79	p12a	Wind / Light	Knowledge that the propagation of light is not influenced by wind.
80	p12b	Magnet / Light	Knowledge that the propagation of light is not influenced by magnetic force.
81	p02	Gravity affects all objects	Knowledge that gravity affects all objects to the same extent, independent from their weight. Knowledge that light is not affected by gravity.

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82	p08a	Fan	Knowledge of what a fan is and that it produces wind.
83	p08b	Wind	Knowledge of what wind is.

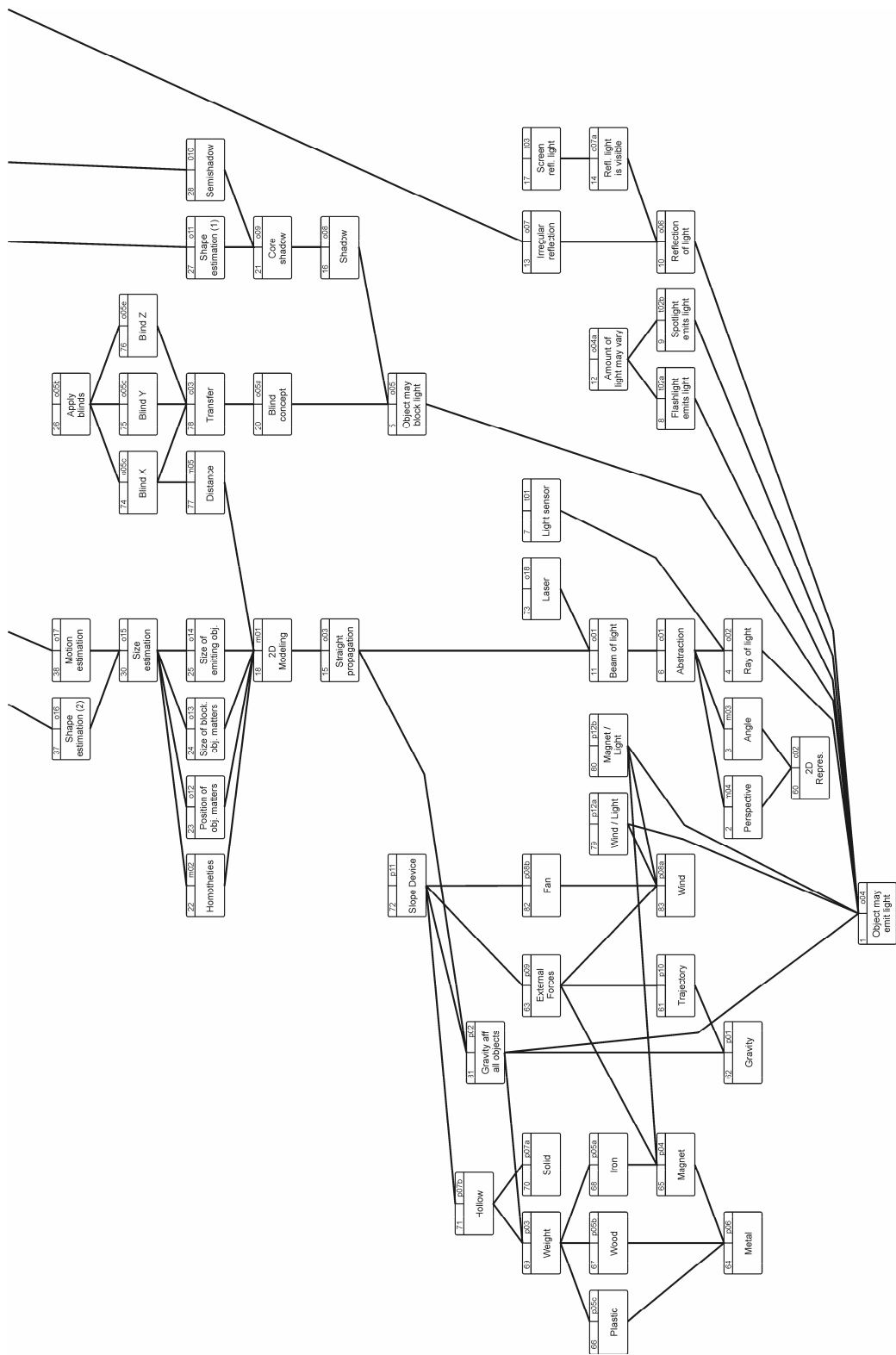


Figure 1. Prerequisite relation between skills of the original skill list.



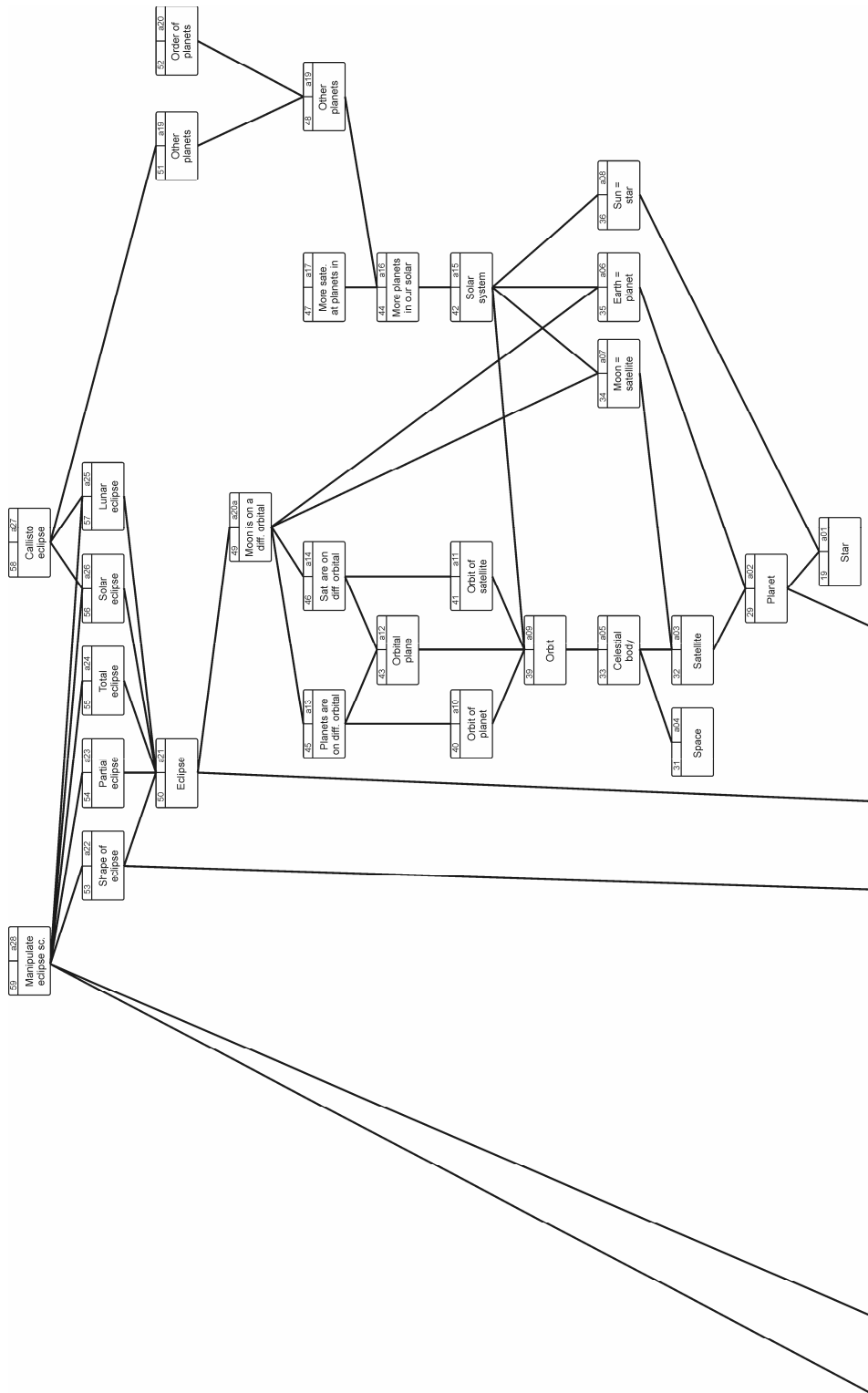


Figure 1 (continued). Prerequisite relation between skills of the original skill list.

## **2.2 *Reduced and revised version***

The skill structure resulting from the skills in Table 1 and the skill structure illustrated in Figure 1 has a number of skill states beyond ten million. Partially, single skills cannot be uncovered on the basis of the LeS in the intermediate demonstrator. Thus, a reduced and more efficient version of the skill list and the corresponding prerequisite relation has been developed. In this version 31 skills (on a less fine level of granularity) are specified. In addition, skills have been revised in order to meet the requirements of an efficient and effective intervention within the game. The reduced skill list is shown in Table 2, the corresponding prerequisite relation in Figure 2a. This prerequisite relation establishes 560.249 skill states. Table 3 includes the binary matrix of the prerequisite relation's basis. Table 4 demonstrates the mapping of skills and LeS.

Table 2. *Reduced set of skills related to the intermediate game demonstrator.*

Nr.	Symbol	Abbreviation	Description
1	p06	Solid	Knowledge what a solid object is.
2	g02	Torch	Knowledge that a torch emits light.
3	g04	Spotlight	Knowledge that a spotlight emits light.
4	g05	Light sensor	Understanding of what a light sensor is.
5	p01	Gravity	Knowledge that gravity attracts all objects independent from their weight or material and makes them fall following a certain trajectory. Knowledge that gravity does not affect the propagation of light.
6	p05	Hollow	Knowledge what a hollow object is and that it is less heavy than a solid object.
7	o01	Light cone	Knowledge that light propagates in form of a light cone.
8	g09	Fan	Knowledge that a Fan produces wind; the wind, in turn, may influence the trajectory of a falling object (countering gravity) depending on its weight and the fan's power.
9	g10	Magnet	Knowledge that a magnet attracts metals but no other materials; magnetic force may influence the trajectory of a falling metal object (countering gravity) depending on the magnetic power and the object's weight.
10	g08	Laser	Knowledge that a laser is a light source emitting a narrow beam of light instead of a light cone.
11	o02	Blind	Understand the mechanisms of a blind, i.e., to narrow a ray of light. This skill includes the knowledge that blinds must be ordered by an decreasing size of aperture (from the direction of the light source).
12	g01	Blind task / requ. light	Understand the task of LeS 1.3.1 (to narrow a light cone into a narrow beam of light) and understand that this task requires a light source.
13	g03	Door task / requ. light	Understand the task of LeS 1.3.3 (to open the door using a beam of light) and understand that this task requires a light source.
14	g07	Slope task	Understand the task of LeS 1.2.1 (making balls of different materials fall into a basket).
15a	p02a	Plastic_fan	Knowledge of what plastic is and that it is a light material, which can easily be influenced by wind.
15b	p02b	Plastic_magnet	Knowledge of what plastic is and that it is not a metal and therefore is not influenced by a magnet.

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16a	p03a	Wood_fan	Knowledge of what wood is and that it is medium heavy material, which can be influenced by wind.
16b	p03b	Wood_magnet	Knowledge of what wood is and that it is not a metal and therefore is not influenced by a magnet.
17a	p04a	Iron_fan	Knowledge of what iron is and that it is a heavy material, which is little influenced by wind.
17b	p04b	Iron_magnet	Knowledge of what iron is and that it is a metal and therefore influenced by a magnet.
18	o03	Blind X	Understanding of the effects of moving a blind along the x axis (closer and farther from light source and screen).
19	o04	Blind Y	Understanding of the effects of moving a blind along the y axis (to the left and right in relation to light source and screen).
20	o05	Blind Z	Understanding of the effects of moving a blind along the z axis (up and down in relation to light source and screen).
21a	m01	2D Model	Understand 2D representations of a situation. This knowledge includes understanding of different perspectives.
21b	m01_b	3D Model	Understand 3D representations of a situation. This knowledge includes understanding of different perspectives.
22	c01	Transfer	Being able to transfer the knowledge about blinds and the effects of manipulating blinds in the 3D space to another situation.
23	g06	Slope device	Being able to use the related knowledge to successfully operate the slope device (according to LeS 1.2.1).
24	o06	Straight prop. of light	Conscious understanding that light propagates in a straight line unaffected by gravity or other external forces such as magnetic force or wind. Knowledge about the blind concept and understanding of related 2D representations. Knowledge about the link between the straight and unaffected propagation of light and the blind concept.
25a	p07_a	Stone_fan	Knowledge of what stone is and that it is a medium heavy material, which can be influenced by wind.
25b	p07_b	Stone_magnet	Knowledge of what stone is and that it is not a metal and therefore is not influenced by a magnet.
26a	p08_a	Light_fan	Knowledge that the emission of light is not influenced by wind.
26b	p08_b	Light_magnet	Knowledge that the emission of light is not influenced by magnetic force.

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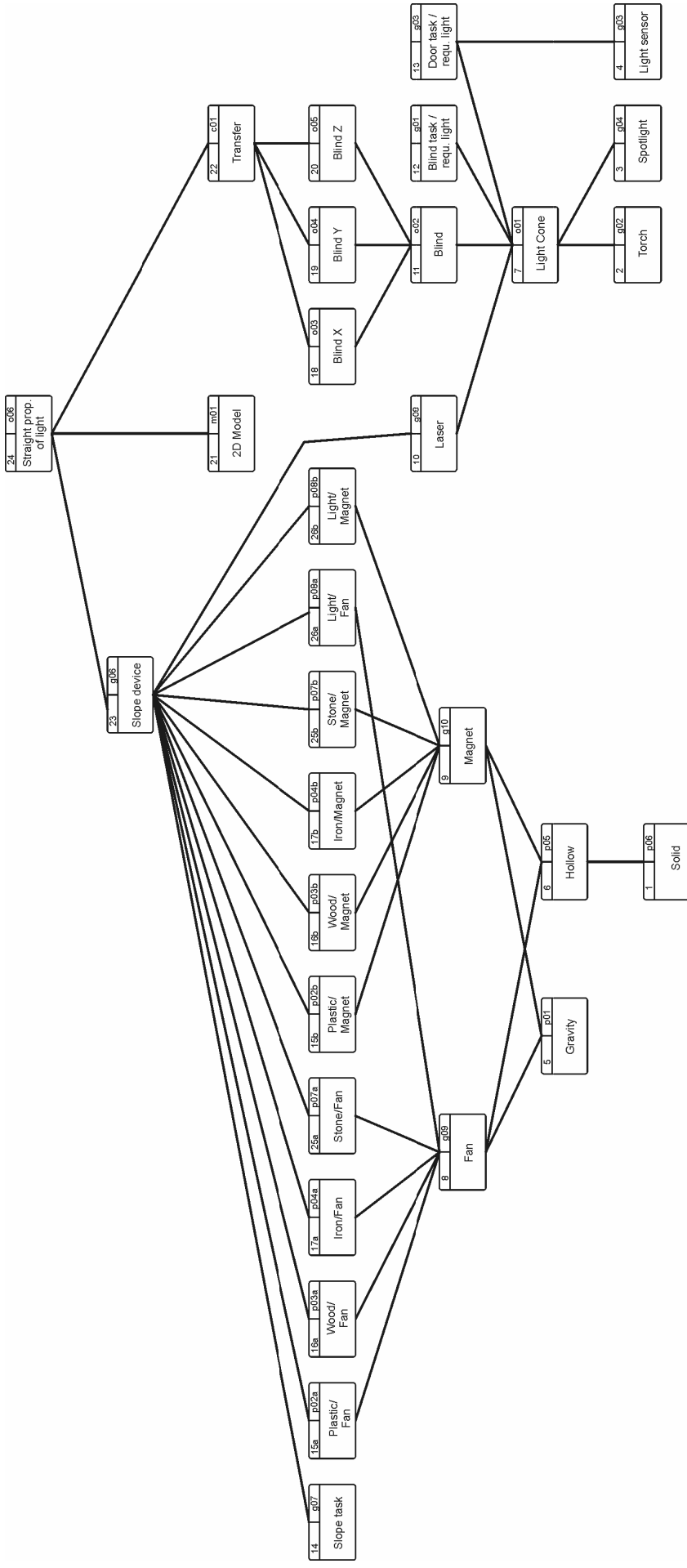


Figure 2a. Prerequisite relation for the reduced set of skills related to the intermediate game demonstrator.

Table 3. *Basis of the prerequisite relation in Figure 2a.*

1000000000000000000000000000000000000000
0100000000000000000000000000000000000000
0010000000000000000000000000000000000000
0001000000000000000000000000000000000000
0000100000000000000000000000000000000000
1000010000000000000000000000000000000000
0110001000000000000000000000000000000000
1000110100000000000000000000000000000000
1000110010000000000000000000000000000000
0110001001000000000000000000000000000000
0110001000100000000000000000000000000000
0110001000010000000000000000000000000000
0111001000001000000000000000000000000000
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0110001000100000000000000010000000000000
0110001000100000000000000000100000000000
01100010001000000000000000000010000000
000000000000000000000000000000000001000
01100010001000000000000000001110100
111011111100011111111111110000010
11101111111001111111111111111111

### 2.3 Assignment of skills to LeS

Table 4. Mapping between skills and LeS.

LeS	Included skills (see Table 2 for descriptions)
1.2.1	1, 5, 6, 8, 9, 10, 14, 15a, 16a, 17a, 15b, 16b, 17b, 25a, 26a, 25b, 26b*
1.2.3	2, 3, 7, 11, 12, 18, 19, 20
1.3.1	2, 3, 7, 11, 12, 18, 21
1.3.3	2, 3, 4, 7, 11, 13, 18, 19, 20, 21, 22

Note: See also Figures 2b, 2c, 2d, and 2e.

\*Although according to the whole ontology skills 2, 3, and 7 are prerequisites for skill 10 (see Figure 2a), these skills will not be considered in LeS 1.2.1 since these skills are not explicitly taught in this situation (see also Figure 2b).

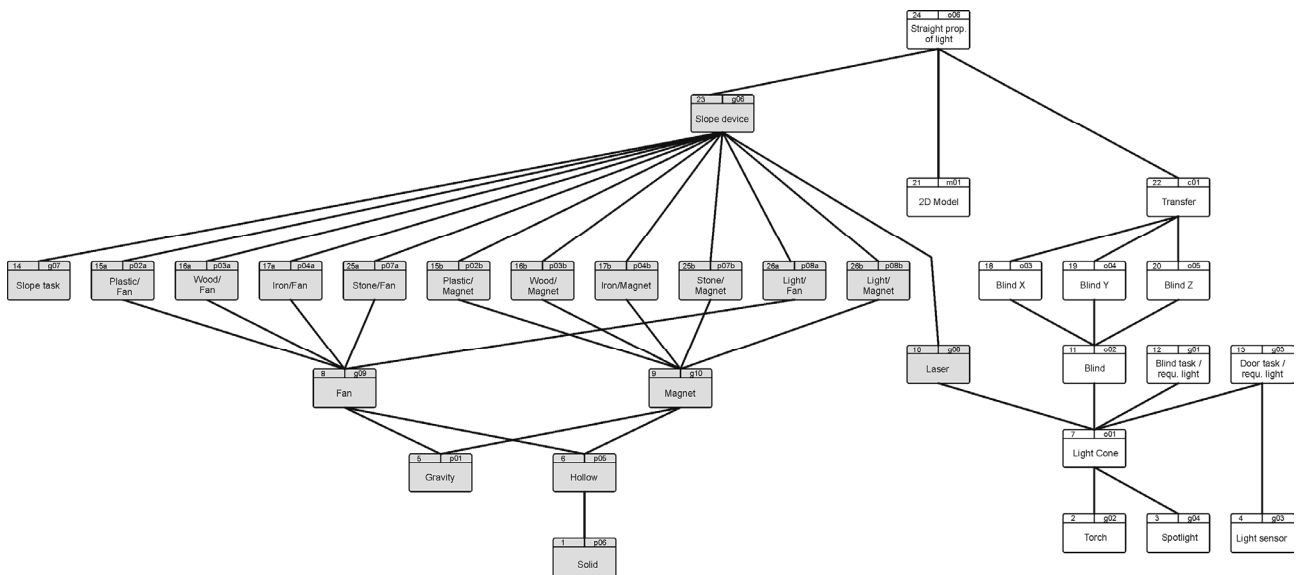


Figure 2b. Skills involved (greyed) in LeS 1.2.1 (see also Table 4).

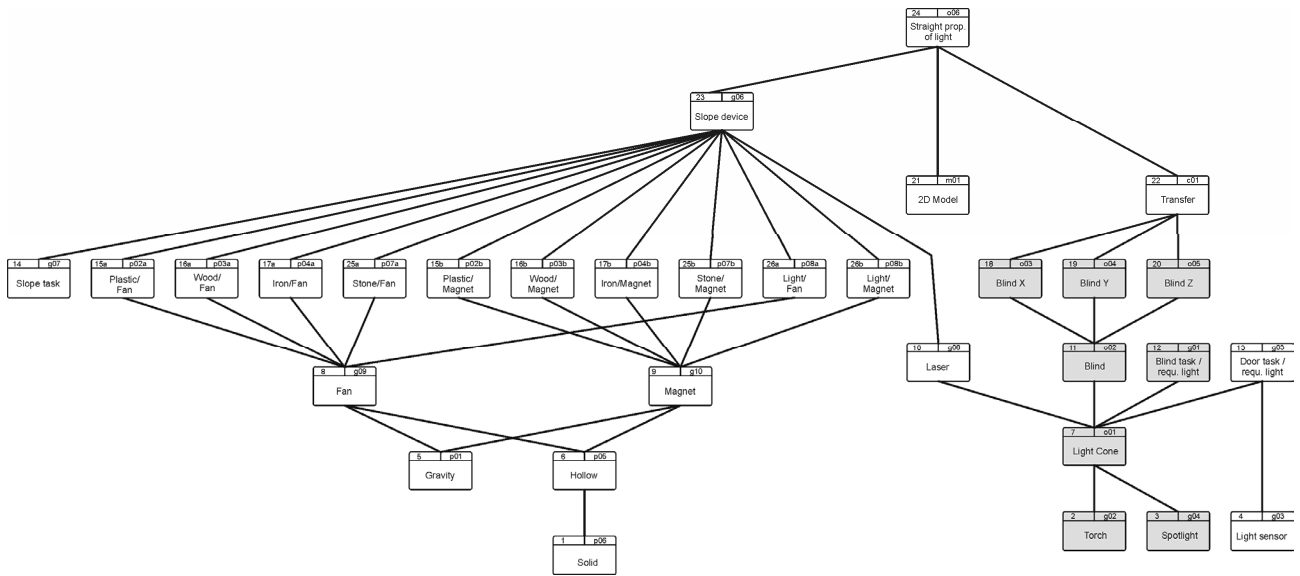


Figure 2c. Skills involved (greyed) in LeS 1.2.3 (see also Table 4).

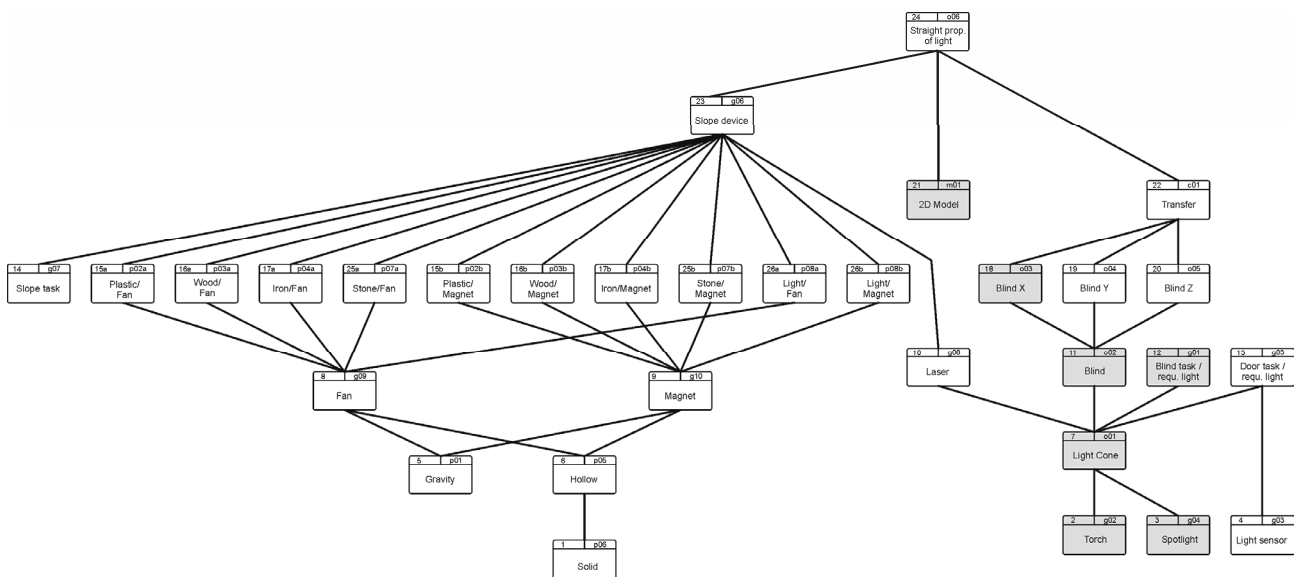


Figure 2d. Skills involved (greyed) in LeS 1.3.1 (see also Table 4).



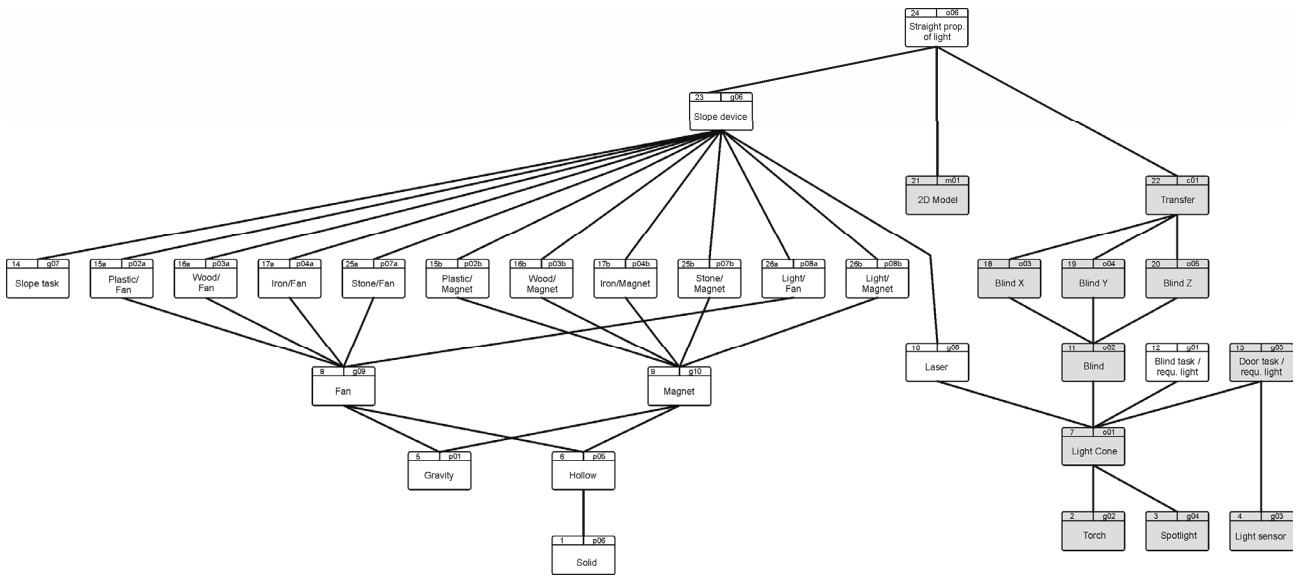


Figure 2e. Skills involved (greyed) in LeS 1.3.3 (see also Table 4).

The skills, the prerequisite relation between them, and the resulting skill structure are the basis of the ELEKTRA ontology version VIII.