Supplementary Material

Table S1. Synthesis of GA lists as reported in the overviews [20,21].

[14]*	[15, p. 713]*	[16, pp. 833–835]	[17, p. 251]	[18, pp. 4-6*]	[19, p. 45]	[20, p. 215]	[26, p. 990] (SUSSI conception)
“Scientific knowledge is tentative”	“Science and Certainty”	“Scientific knowledge is never absolute or certain but tentative and subject to change.”	• “Scientific knowledge is tentative, durable, and self-correcting” • “Science and its methods cannot answer all questions.”	—	“Science is tentative/fallible.”	tentativeness	“scientific knowledge is tentative and subject to change”
“Science relies on empirical evidence”	“Analysis and Interpretation of Data”	• “Observation and inference are different.” • “Scientific knowledge is empirical, as it is based on and/or derived from observations of the natural world.”	“Science produces, demands, and relies on empirical evidence”	• “Justification of scientific knowledge.” • “Distinctions between data and evidence.”	• “Observations are theory-laden.” • “Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments and skepticism.”	empirical evidence	“scientific knowledge development involves a combination of observations and inferences”
“Scientists require replicability and truthful reporting”	“Scientific Method and Critical Testing”	—	“Knowledge production in science shares many common factors and shared habits of mind, norms, logical thinking, and methods such as careful observation and data recording, truthfulness in reporting, etc.”	—	“Scientists require accurate record keeping, peer review and replicability.”	scientific quality standards of research	—

"Science is an attempt to explain phenomena"	"Hypothesis and Prediction"	—	—	"Scientific questions guide investigations	—	knowledge gain as goal	—
"Scientists are creative"	• "Creativity" • "Science and Questioning"	Scientific knowledge involves human imagination and creativity.	"Science has a creative component"	—	"Scientists are creative and often resort to imagination and speculation."	creativity	"scientific knowledge development involves human imagination and creativity"
"Science is part of social tradition"	"Cooperation and collaboration in the development of scientific knowledge"	"Scientific knowledge is subjective."	"Science has a subjective element."	"Community of practice."	"Different scientists can interpret the same experimental data in more than one way."	social embeddedness	—
"Science has played an important role in technology"	"Science and Technology"	—	"Science and technology impact each other, but they are not the same"	—	—	interrelation with technology	—
"Scientific ideas have been affected by their social and historical milieu"	"Historical Development of Scientific Knowledge"	"Scientific knowledge is influenced by the cultural contexts in which it is developed."	"There are historical, cultural, and social influences on science"	—	"Scientific ideas are affected by their social and historical milieu."	science in the fabric of society and culture	"scientific knowledge is socially and culturally embedded"
—	"Diversity of Scientific Thinking"	—	—	• "Multiple methods of scientific investigations." • "Multiple purposes of scientific investigations."	"There is no one way to do science and hence no universal step-by-step scientific method can be followed."	diversity	"scientific knowledge development involves the use of diverse scientific methods"

"Changes in science occur gradually"	—	—	—	—	"Scientific progress is characterized by competition among rival theories."	gradual change	—
"Science has global implications"	—	—	—	—	—	global nature	—
"New knowledge must be reported clearly and openly"	—	—	—	—	—	quality standards of publications	—
—	—	"Scientific laws and theories are distinct forms of knowledge."	"Laws and theories are related but distinct kinds of scientific knowledge."	—	"Laws and theories serve different roles in science and hence theories do not become laws even with additional evidence."	theories and laws	"scientific theories and laws are functionally different types of scientific knowledge"
—	—	—	—	"Recognition and handling of anomalous data."	"Development of scientific theories at times is based on inconsistent foundations."	anomalies	—

Note. Articles marked with an asterisk were previously reported in Neumann and Kremer [20]; Grey shading represents how many of the cited authors referred to the specific NOS aspect.

Table S2. Coding scheme for the identification of learning opportunities in module manuals.

NOS aspect (category)	description	example	code
(1) scientific methods	Mastering scientific methods is essential to be able to work scientifically. It is important to be capable of developing questions and formulating hypotheses. In order to confirm unproven assumptions, it is necessary to know how specific research designs can be developed and ultimately applied. Not only the methodology is important, but also knowledge needs to be taken into account. For example, it must be known that an Observer bias must be avoided in order not to misinterpret a result. The data collected must be evaluated and correctly documented so that it is comprehensible and precise. It must be possible to repeat an experiment at any time using the recordings and achieve the same results. In addition, models must be used correctly in order to be able to explain, for example, experimental findings (e.g. design and apply crossroads schemes and family trees).	"Students are able to experiment on the basis of hypotheses" (University B, 2015, p. 5)	*frequency:* A scientific method is explicitly named or scientific work is generally discussed. *credit points:* If the above defined frequency is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(2) tentativeness	Scientific knowledge is constantly changing and therefore modifiable, for example by adapting or updating a theory. Scientific knowledge is never absolutely certain. New insights gained, for example through new technologies, change or broaden the viewpoint. New discoveries and scientific achievements can mean that existing theories need to be reconsidered and possibly reinterpreted. Theories must always be checked several times and have a temporary character. In addition, not all questions can be answered by scientists—there are limitations.	"This evaluation provides an insight into the possibilities and limitations of ecosystem assessment." (University A, p. 80)	*frequency:* If one aspect of the definition of a theory is addressed, this is counted as a learning opportunity. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(3) observations and inferences	It is not possible to name one scientific method that all natural scientists follow, regardless of the subject or field of research they belong to. It is not even the method - in a general sense - that all natural scientists of a subject or sub-discipline follow. Of course, scientists use the same methods and scientific procedures, since there are often well-tried methods in science, but there is a wide variety of methods from which scientists choose very precisely which they want to use. The choice of method always depends on the state of research and the research objective. New methods can lead to new insights, which is why a large repertoire of methods is important.	"Discovering and experiencing the methodological possibilities" (University E, p. 2)	*frequency:* It is explicitly or implicitly pointed out that there are various methodological possibilities for investigations. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.

(4) scientific theories and laws	Scientific theories are recognized, well-founded and consistent constructions of explanations. Both, however, are not hierarchically related. This means that scientific theories do not become laws at some point, even if they have been sufficiently tested. Furthermore, the use of the term theory in everyday language differs from scientific language. In everyday language the word theory means an unsecured consideration, a mere assumption. In science, on the other hand, the term theory is understood as a system of statements which to a certain extent serves to summarize, describe, explain and predict phenomena. Theories summarize and explain many phenomena that they can be identified as scientific knowledge. Laws, on the other hand, are descriptions of observations or predicted relationships of natural phenomena under constant conditions.	—	*frequency:* If it is elucidated that there is no hierarchical relationship between theory and law and/or these are differentiated from each other. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(5) subjectivity and objectivity	Natural sciences are never objective, but always subjective, since the scientific knowledge of scientists is influenced by theoretical efforts, ideas, previous knowledge, training, previous experiences and expectations. It is also a mistake to assume that science begins with objectivity—this is only true in very rare cases.	"Openness with regard to the subjectivity and relativability of knowledge resources." (University K, p. 27)	*frequency:* The category is met, if the influence of subjectivity on science is addressed. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(6) social and cultural embeddedness	Science is influenced by social aspects and the culture and values in which it is applied. Society sets the rules for research to be carried out. If scientists leave this common canon of values, this can lead to a contempt for work. In addition, society and culture make implicit and explicit demands on research, for example which problems should be researched first, i.e. for example the investigation and potential cure of a local disease which society considers important. These demands give rise to questions and considerations by which scientists are guided. However, research is not only influenced by the moral requirements of society, but also, for example, by the history and financial resources available. Nevertheless, the values generated in culture and society do not only have an impact on the research process, but also on how potential scientific results are dealt with or perceived in society.	"legal foundations of human genetic activities" (University M, p. 5)	*frequency:* If it is addressed that society socially, culturally or historically influences science, the category is met. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.

(7) creativity and imagination	Creativity and imagination are two vital aspects in every research stage. They are essential for the generation of new questions and hypotheses—and in the event of possible failure or stagnation, a new possible solutions can be devised, for example by creating an improved experimental set-up that enables new research or simplifies it. Creativity also plays an important role in the evaluation of acquired data, since without the creative combination of knowledge it would be difficult to gain new insights and interpret unexpected results.	"Discussing issues from different perspectives" (University E, 2015, p. 9)	*frequency:* Creativity as a feature of science is brought up as a theme. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(8) nature of knowledge	This dimension of epistemological beliefs divides into certainty of knowledge, i.e. that knowledge is dynamic and changeable and into complexity of knowledge (simplicity of knowledge), which encompasses the perception of the complexity of interrelations in knowledge concepts.	"Understanding biological issues in different contexts" (University E, 2015, p. 8)	*frequency:* The category is met, if knowledge is addressed as being changeable and interrelated. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.
(9) nature of knowing	This dimension of epistemological beliefs divides into the area of source of knowledge—which focuses on the perspective on knowledge as an externally presented or self-constructed construct— and justification for knowing—which includes the handling of assertions of experts or evidence.	"to conduct literature research and data evaluation autonomously." (University M, p. 5)	*frequency:* If students are required to generate knowledge or reflect about knowledge, the category is met. *credit points:* If the above defined condition is fulfilled, the credit points of the module are noted. The credit points are added up and recorded as a total.

Note. The names of universities are blinded.