Understanding Science Conceptual Framework

This list of conceptual understandings regarding the nature and process of science is aligned across grade levels to help instructors identify age-appropriate learning goals for their students and understand how concepts taught at one grade level lay the groundwork for more sophisticated concepts later on. The conceptual framework is aligned with the 2012 Framework for K-12 Science Education and the Next Generation Science Standards (NGSS). In the table below, conceptual alignment is indicated by a code that follows each aligned concept. For example, P3 indicates correspondence to "Planning and carrying out investigations," the third of eight Science and Engineering Practices listed in those documents, and NOS2 indicates correspondence to the second concept outlined in NGSS's appendix on the nature of science, "Scientific knowledge is based on empirical evidence."

What is science?				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
Science is both a body of knowledge and the process for building that knowledge.	**Science is both a body of knowledge and the process for building that knowledge. (NOS5)**	**Science is both a body of knowledge and the process for building that knowledge. (NOS5)**	**Science is both a body of knowledge and the process for building that knowledge. (NOS5)**	**Science is both a body of knowledge and the process for building that knowledge.**
Scientists ask and address questions. (P1, P3, NOS4)	**Scientists ask and address questions. (P1, P3, NOS4)**	**Science aims to build explanations of the natural world. (P3, P6)** Science deals with the natural world and natural explanations.	**Science aims to build explanations of the natural world. (P3, P6)** Science focuses on natural phenomena and processes.	**Science aims to build increasingly broad and coherent explanations of the natural world.** Science focuses on natural phenomena and processes.
		Science works only with testable ideas. (P2, P3, NOS2)	**Science works only with testable ideas. (P2, P3, NOS2)** Moral judgments, aesthetic judgments, decisions about applications of science, and conclusions about the supernatural are outside the realm of science. (NOS8)	**Science works only with testable ideas.** Moral judgments, aesthetic judgments, decisions about applications of science, and conclusions about the supernatural are outside the realm of science.
Scientists base their ideas on evidence from the natural world. (P3)	**Scientists base their ideas on evidence from the natural world. (P3)**	**Scientists strive to test their ideas with evidence from the natural world; a hallmark of science is exposing ideas to testing. (P3, P4, P6, P7, NOS2)**	**Scientists strive to test their ideas with evidence from the natural world; a hallmark of science is exposing ideas to testing. (P3, P4, P6, P7, NOS2)**	**Scientists strive to test their ideas with evidence from the natural world; a hallmark of science is exposing ideas to testing.**

What is science? (cont.)				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
Scientific ideas may change based on what we observe and experience. (NOS3)	**Scientific ideas may change with new evidence. (NOS3)**	**Scientific knowledge is open to question and revision as new ideas surface and new evidence is discovered. (P6, NOS3)** Scientific ideas cannot be absolutely proven. Because it has been tested, scientific knowledge is reliable.	**Scientific knowledge is open to question and revision as new ideas surface and new evidence is discovered. (P4, P6, NOS3)** Scientific ideas cannot be absolutely proven. Because it has been tested, scientific knowledge is reliable. (NOS3)	**Scientific knowledge is open to question and revision as new ideas surface and new evidence is discovered.** Scientific ideas cannot be absolutely proven. Because it has been tested, scientific knowledge is reliable.
	Answering one question often leads to other questions.	**Science is ongoing; answering one scientific question frequently leads to additional questions to be investigated.**	**Science is ongoing; answering one scientific question frequently leads to additional questions to be investigated.**	**Science is ongoing; answering one scientific question frequently leads to additional questions to be investigated.**

How science works				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
		The *real* process of science is complex, iterative, and can take many different paths.	**The *real* process of science is complex, iterative, and can take many different paths.**	**The *real* process of science is complex, iterative, and can take many different paths.**
Scientists observe, explore, discover, and communicate with one another.	**Scientists observe, explore, discover, and communicate with one another.**	**The process of science involves observation, exploration, testing, communication, and application.**	**The process of science involves observation, exploration, testing, communication, and application.**	**The process of science involves observation, exploration, testing, communication, and application.**
Scientific observations can be made directly with our own senses or may be made indirectly through the use of tools. (P3)	**Scientific observations can be made directly with our own senses or may be made indirectly through the use of tools. (P3)**	**Scientific observations can be made directly with our own senses or may be made indirectly through the use of tools.**	**Scientific observations can be made directly with our own senses or may be made indirectly through the use of tools.**	**Scientific observations can be made directly with our own senses or may be made indirectly through the use of tools.**
		Scientists test their ideas by predicting what they would expect to observe if their idea were true and then seeing if that prediction is correct. (P4, P6) Scientists can test ideas about events and processes long past, very distant, and not directly observable. Scientists test their ideas using multiple lines of evidence.	**Scientists test their ideas (hypotheses and theories) by figuring out what expectations are generated by an idea and making observations to find out whether those expectations are borne out. (P4, P6)** Scientists can test ideas about events and processes long past, very distant, and not directly observable. Scientists test their ideas using multiple lines of evidence. (P6, NOS2)	**Scientists test their ideas (hypotheses and theories) by figuring out what expectations are generated by an idea and making observations to find out whether those expectations are borne out.** Scientists can test ideas about events and processes long past, very distant, and not directly observable. Scientists test their ideas using multiple lines of evidence. All scientific tests involve making assumptions, but these assumptions can be independently tested, increasing our confidence in our test results.
		Scientists often try to generate multiple explanations for what they observe. (P7)	**Scientists often try to generate multiple explanations for what they observe. (P7)**	**Scientists often try to generate multiple explanations for what they observe.**

How science works (cont.)				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
		Scientists use multiple research methods (experiments, observations, comparisons, and modeling) to collect evidence. (P2, P3, P4, NOS1)	**Scientists use multiple research methods (experiments, observational research, comparative research, and modeling) to collect data. (P2, P3, P4, NOS1)**	**Scientists use multiple research methods (experiments, observational research, comparative research, and modeling) to collect data.**
Scientists look for patterns in what they observe. (P4, P5, NOS2)	**Scientists look for patterns in what they observe. (P1, P4, P5, NOS2)**	**Scientists look for patterns in their observations and data. (P4, P5)** Raw data must be analyzed and interpreted before we can tell whether a scientific idea is likely to be accurate or inaccurate. (P4, P5)	**Scientists look for patterns in their observations and data. (P4, P5, NOS2)** Raw data must be analyzed and interpreted before we can tell whether a scientific idea is likely to be accurate or inaccurate. (P4, P5) Analysis of data usually involves putting data into a more easily accessible format (visualization, tabulation, or quantification of qualitative data). (P4, P5)	**Scientists look for patterns in their observations and data.** Raw data must be analyzed and interpreted before we can tell whether a scientific idea is likely to be accurate or inaccurate. Analysis of data usually involves putting data into a more easily accessible format (visualization, tabulation, or quantification of qualitative data).
		Scientists try to be objective and work to identify and avoid bias.	**Scientists try to be objective and work to identify and avoid bias.**	**Scientists try to be objective and work to identify and avoid bias.**
Scientists don't always agree with one another. (P7)	**Scientists don't always agree with one another. (P7)**	**Different scientists may interpret the same data in different ways. (P7)**	**Different scientists may interpret the same data in different ways. (P7)**	**Different scientists may interpret the same data in different ways; data interpretation can be influenced by a scientist's assumptions, biases, and background.**
			Researchers share their findings with the scientific community through scientific publications. (P8)	**Researchers share their findings with the scientific community through scientific publications.**

How science works (cont.)				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
		Scientists aim for their studies to be replicable.	**Scientists aim for their studies to be replicable.** When a study of a phenomenon cannot be replicated, it may suggest that our current understanding of the phenomenon or our methods of testing are insufficient.	**Scientists aim for their studies to be replicable.** When a study of a phenomenon cannot be replicated, it may suggest that our current understanding of the phenomenon or our methods of testing are insufficient.

Hypotheses and theories				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
		Hypotheses are potential explanations for what we observe in the natural world. (P6) Hypotheses are usually inspired and informed by previous research and/or observations. They are not guesses. (P6)	**Hypotheses are proposed explanations for a narrow set of phenomena. (P6)** Hypotheses are usually inspired and informed by previous research and/or observations. They are not guesses. (P6)	**Hypotheses are proposed explanations for a narrow set of phenomena.** Hypotheses are usually inspired and informed by previous research and/or observations. They are not guesses.
			Theories are powerful explanations for a wide range of phenomena. (P6, NOS4)	**Theories are powerful explanations for a wide range of phenomena.**
		Accepted scientific theories are not tenuous; they must survive rigorous testing and be supported by multiple lines of evidence to be accepted. (P6, NOS4)	**Accepted scientific theories are not tenuous; they must survive rigorous testing and be supported by multiple lines of evidence to be accepted. (P6, NOS2, NOS4)**	**Accepted scientific theories are not tenuous; they must survive rigorous testing and be supported by multiple lines of evidence to be accepted.**

The social side of science				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
Scientists share their ideas with each other. (P7, P8)	**Scientists explain their ideas and evidence to one another. (P7, P8)**	**Science depends on communication within the scientific community. (P7, P8)**	**Science depends on communication within the scientific community. (P7, P8)**	**Science depends on communication within the scientific community.**
Scientists work together.	**Scientists work together.**	**Scientists usually work collaboratively.**	**Scientists usually work collabora tively. (NOS7)**	**Scientists usually work collaboratively.**
		Scientists check each other's work, often through peer review. (P7)	**Scientists scrutinize each other's work through peer review and other processes. (P7, NOS5)** Through a system of checks and balances (which includes peer review), the scientific community helps ensure science's accuracy and helps detect bias, fraud, and misconduct. (P7, NOS5)	**Scientists scrutinize each other's work through peer review and other processes.** Through a system of checks and balances (which includes peer review), the scientific community helps ensure science's accuracy and helps detect bias, fraud, and misconduct.
				The scientific community motivates researchers in their investigations by providing recognition and, sometimes, a sense of competition.
			Science relies on the accumulated knowledge of the scientific community to move forward. (NOS5)	**Science relies on the accumulated knowledge of the scientific community to move forward.**
Many different sorts of people do science. (NOS7)	**The scientific community is diverse. (NOS7)**	**The scientific community is global and diverse. (NOS7)**	**The scientific community is global and diverse. (NOS7)** The diversity of the scientific community helps facilitate specialization and provides different points of view that invigorate problem solving and balance biases. Scientists are influenced by their personal experiences and cultures. **(**NOS7)	**The scientific community is global and diverse.** The diversity of the scientific community helps facilitate specialization and provides different points of view that invigorate problem solving and balance biases. Scientists are influenced by their personal experiences and cultures.

The social side of science (cont.)				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
Anyone can do science.	**Anyone can do science.**	**Anyone can participate in science.**	**Anyone can participate in science, but the pursuit of science as a career often requires extensive formal training.**	**Anyone can participate in science, but the pursuit of science as a career often requires extensive formal training.**
Scientsts are creative.	**Scientists are creative. (NOS7)**	**Scientists are creative. (NOS7)**	**Scientists are creative. (NOS7)**	**Scientists are creative.**
				Scientific misconduct can occur when a scientist doesn't fairly evaluate other scientists' work, doesn't honestly report results, doesn't fairly assign credit, or doesn't work within the ethical guidelines of the community.

Science and society				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
			Science is embedded in, and influenced by, the broader society. (NOS7) Scientific research is often focused on topics with the potential to help meet societal needs.	**Science is embedded in, and influenced by, the broader society.** Societies may influence the course of science by directing funds towards some research topics and away from others. Scientific research is often focused on topics with the potential to help meet societal needs.

What has science done for you lately				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
			Science builds knowledge about the world, but people decide how that knowledge should be used. (NOS8)	**Science builds knowledge about the world, but people decide how that knowledge should be used.**
People benefit from knowledge gained through science.	**People benefit from knowledge gained through science.**	**Science contributes to many different sorts of new technologies.** Advances in science often drive technological innovations, which may, in turn, contribute to new scientific discoveries. (NOS7)	**Science contributes to many different sorts of new technologies.** Advances in science often drive technological innovations, which may, in turn, contribute to new scientific discoveries. (NOS7)	**Science contributes to many different sorts of new technologies.** Advances in science often drive technological innovations, which may, in turn, contribute to new scientific discoveries.
		Scientific knowledge and research have led to many medical advances.	**Scientific knowledge and research have led to many medical advances.**	**Scientific knowledge and research have led to many medical advances.**
		Scientific knowledge helps us make decisions that affect our lives every day.	**Scientific knowledge helps us make decisions that affect our lives every day.**	**Scientific knowledge helps us make decisions that affect our lives every day.**
		Scientific knowledge informs public policies and regulations that promote our health, safety, and environmental stewardship. (NOS8)	**Scientific knowledge informs public policies and regulations that promote our health, safety, and environmental stewardship.**	**Scientific knowledge informs public policies and regulations that promote our health, safety, and environmental stewardship.**

A scientific approach to life				
K-2	**3-5**	**6-8**	**9-12**	**13-16**
	Problem-solving and decision-making benefit from a scientific approach.	**Problem-solving and decision-making benefit from a scientific approach.**	**Problem-solving and decision-making benefit from a scientific approach.**	**Problem-solving and decision-making benefit from a scientific approach.**
				Authentic scientific controversy and debate within the community contribute to scientific progress by encouraging careful examination of the research.
			Controversies about the ethicality of particular scientific methods or about the applications of scientific ideas may occur within the broader society, but do not necessarily represent a rift in science. (NOS8)	**Controversies about the ethicality of particular scientific methods or about the applications of scientific ideas may occur within the broader society, but do not necessarily represent a rift in science.**