Example	**Empirical nature 1.empirical 2.non-empirical 3.both 4.unclear**	**Source 1.first-hand 2.first and second-hand 3.second hand 4.unclear**	**Inferential process 1.clear concern about inferential process; 2.no clear concern**	**Interpretation of Example**
Framework-1(p. 43) G Seeing science as a set of practices shows that theory development, reasoning, and testing are components of a larger ensemble of activities that includes networks of participants and institutions, specialized ways of talking and writing, the development of models to represent systems or phenomena, the *making of predictive inferences*, construction of appropriate instrumentation, and *testing of hypotheses* by experiment or observation.	4	4	1	This is a general statement about what it means to see science as a set of practices. Here "the making of predictive inference" and "testing of hypotheses" are two clauses embedding the idea of evidence use. While hypothesis testing "by experiment or observation" definitely involves the use of empirical data, it is unclear on what basis predictive inferences should be made, and what would serve as the appropriate sources of supporting information. This clause, however, confirms that the inferential process is an important part of theory development and reasoning
Framework-2 (p. 44) E "However, as all ideas in science are evaluated against alternative explanations and compared with evidence, acceptance of an explanation is ultimately an assessment of what data are reliable and relevant and a decision about which explanation is the most satisfactory."	1	2	1	This is situated in the text that emphasizes the role of critique in science. The first half of the sentence ("ideas…are compared with evidence") does not clearly suggest the nature or source of the evidence, the second half of the sentence makes it clear that the assessment is on "what data are reliable and relevant", which foregrounds empirical evidence from any source. The practice of assessing which explanation is "most satisfactory" implies that some data may serve as evidence for different explanations, embedding a concern for the inferential process in evidence construction.
Framework-3 (p. 44) E/A	1	4	2	This is in the same paragraph as the

"Engaging in argumentation from evidence about an explanation supports students' understanding of the reasons and empirical evidence for that explanation, demonstrating that science is a body of knowledge rooted in evidence."				example above. It explains the goal of engaging students in argumentation from evidence as supporting their "understanding of reasons and empirical evidence" for explanation. It clearly puts emphasis on empirical evidence but did not show clear consideration about its sources or inferential process.
Framework-4(p. 44) A And in the third sphere, the ideas, such as the fit of models and explanations to evidence or the appropriateness of product designs, are analyzed, debated, and evaluated [21-23].	4	4	2	Here the third sphere refers to "evaluating" in figure 3-1, which contains the practices of "argue, critique and analyze." The use of the evidence here conveys no clear message about the nature, the sources, or the inferential process.
Framework-5(p. 45) E/M For scientists, their work in this sphere of activity is to draw from established theories and models and to propose extensions to theory or create new models.	2	3	2	This is a description of practices in the second sphere, that is, "developing explanations and solutions." It did not use the term evidence, but suggests that work in this sphere should "draw from established theories and models." Functionally the non-empirical, second-hand prior knowledge/ information about theory and models serve as evidence that supports the creation of "extensions of theory" and "new models" here
Framework-6(p. 46) A Scientists and engineers use evidence-based argumentation to make the case for their ideas, whether involving new theories or designs, novel ways of collecting data, or interpretations of evidence.	4	4	1	This appears in the context of emphasizing how the practice of evaluation should "repeats at every step of the work." "Interpretation of evidence" has been explicitly mentioned within the different types of work numerated, which showed clear concern about the inferential process involved. It suggested that scientists can "use evidence-based argumentation to make the case for" various types of ideas, with no clear message about the source or nature of evidence.
Framework-7(p. 48) A Although we do not expect	3	4	2	Here it suggested that students should argue using both "theory-based models"

K-12 students to be able to develop new scientific theories, we do expect that they can develop theory-based models and argue using them, in conjunction with evidence from observations, to develop explanations. Indeed, developing evidence-based models, arguments, and explanations is key to both developing and demonstrating understanding of an accepted scientific viewpoint.				and "evidence from observations" to develop explanations. The former seems to refer to non-empirical prior knowledge about theories, while the latter refers to empirical evidence. There is no clear message about the source or the inferential process.
Framework-8(p. 50) Q A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered.	1	4	2	Here the practice of "asking question" is described as "formulating empirically answerable questions," which explicitly foregrounds the seek for empirical evidence. There is no clear confinement about the source of empirical evidence or concern about the inferential process.
Framework-9(p. 50) I Observations and data collected from such work are used to test existing theories and explanations or to revise and develop new ones.	1	1	2	This is describing the function of scientific investigation, which focuses on students planning and carrying out (first-hand) empirical data collection activities. No reference to the inferential process of evidence construction. Theories are directly tested against data from observations.
Framework-10(p. 51) An Because data usually do not speak for themselves, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data	1	4	1	This is describing the practice of analyzing and interpreting data. It is therefore focusing on inferring from empirical data. There is no confinement about the source

Framework-11(p. 52) E The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.	1	4	1	This is describing the goal of explanation construction. The non-empirical information such as prior knowledge should be included in students' current understanding, and evidence should refer to empirical evidence only. But notice it suggests that both should be included in explanation construction. And since explanations (in plural form) can be consistent with evidence, an inferential process is implied. There is no clear message about the source.
Framework-12(p.52) A Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.	1	4	1	This is describing the nature of argument from evidence. "Formulate evidence based on a solid foundation of data" clearly denotes the process of inferring evidence from empirical data. It did not confine the source of such data.
Framework-13(p.55) Q The experience of learning science and engineering should therefore develop students' ability to ask—and indeed, encourage them to ask—well-formulated questions that can be investigated empirically.	1	1	2	The emphasis in asking questions is to formulate questions that can be answered by empirical investigation, that is, through first hand collection of empirical data, which can give rise to empirical evidence. No concern is shown about the inferential process of evidence construction.
Framework-14(p. 55) Q Ask probing questions that seek to identify the premises of an argument, request further elaboration, refine a research question or engineering problem, or challenge the interpretation of a data set—for example: How do you know? What	4	4	1	Here it is about asking probing question rather than testable question. Probing question is defined as "seek to identify the premises of an argument", which can be information from many resources. "Challenge the interpretation of a data set" showed the concern about inferential process of evidence construction. "Further elaboration" can refer to many things, including personal prior knowledge.

evidence supports that argument?				Following the question "how do you know," "evidence supports the argument" also show no clear message of nature and source of supporting information.
Framework-15 (p. 56) Q As a result, students will become increasingly proficient at posing questions that request relevant empirical evidence; that seek to refine a model, an explanation, or an engineering problem; or that challenge the premise of an argument or the suitability of a design.	1	4	2	Here it lays out the progression of question asking. It seems that the goal is to foster the proficiency of posing different types of questions: there can be questions requesting empirical evidence (without confinement of sources) and questions that do not get at that.
Framework-16 (p. 57) M Models can be evaluated and refined through an iterative cycle of comparing their predictions with the real world and then adjusting them, thereby potentially yielding insights into the phenomenon being modeled.	1	4	2	The way to test model is to compare "predictions with the real world." Here the real world seems to refer to empirical evidence gained through investigations in the real world. There is no confinement of resources and no mention of the inferential process.
Framework-17 (p. 58) M Discuss the limitations and precision of a model as the representation of a system, process, or design and suggest ways in which the model might be improved to better fit available evidence or better reflect a design's specifications. Refine a model in light of empirical evidence or criticism to improve its quality and explanatory power.	4	2	2	Here in the first sentence there is not much confinement on the term "available evidence." The second sentence seems to emphasize "empirical evidence and criticism." The latter should be second-hand but it is not quite clear whether it can be based on non-empirical prior knowledge. There is no mention of inferredness.
Framework-18 (p. 59) M The quality of a student-developed model will be highly dependent on prior	2	3	2	Here it suggested that quality of model would depend on prior knowledge and understanding, indicating that such non-empirical information from second-hand

knowledge and skill and also on the student's understanding of the system being modeled, so students should be expected to refine their models as their understanding develops.				sources would serve as the basis for model construction. Although it did not use the term evidence, functionally it puts prior knowledge in that position.
Framework-19 (p. 59) I The second goal requires investigations to test explanatory models of the world and their predictions and whether the inferences suggested by these models are supported by data.	1	1	2	Here it describes the goal of investigation as testing whether the explanations/ inferences are "supported by data," foregrounding the empirical nature of supports without mentioning the inferredness. And since investigation is where this is going to happen, it should be safe to assume that the data comes from investigation.
Framework-20 (p. 59) I Planning and designing such investigations require the ability to design experimental or observational inquiries that are appropriate to answering the question being asked or testing a hypothesis that has been formed.	1	1	2	"experimental or observational inquiries" apparently would provide first-hand empirical data, which are needed for "answering questions and testing hypothesis." There is no mention of inferredness.
Framework-21(p. 60) I Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources	1	1	2	The emphasis is on questions answerable through first-hand empirical investigation. No mention of inferredness.
Framework-22(p. 61) An Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence.	1	4	1	The inferential process of evidence construction is emphasized, yet the concern is only on the technical approach rather than the theoretical background. Raw data is apparently empirical, without confinement of sources

Framework-23(p. 62) An Analyze data systematically, either to look for salient patterns or to test whether data are consistent with an initial hypothesis.	1	4	1	Consistency with empirical data as test for hypothesis. No confinement on source. “Look for” indicates a reference to the inferential process.
Framework-24(p. 62) An Recognize when data are in conflict with expectations and consider what revisions in the initial model are needed.	1	4	2	Conflict with empirical data serves as evidence challenging the initial model. No confinement on sources and no reference to the inferential process
Framework-25(p. 67) E Although their role is often misunderstood—the informal use of the word “theory,” after all, can mean a guess—scientific theories are constructs based on significant bodies of knowledge and evidence, are revised in light of new evidence, and must withstand significant scrutiny by the scientific community before they are widely accepted and applied.	3	2	2	Here it describes the nature of theory in science as based on significant bodies of “knowledge and evidence.” Non-empirical, second-hand knowledge plays a role, yet not in the name of evidence. It is possible that evidence points to empirical evidence only but there is no clear confirmation in the contexts. No mention of the inferential process.
Framework-26(p. 67) E A hypothesis is made based on existing theoretical understanding relevant to the situation and often also on a specific model for the system in question.	2	3	2	This is talking about the nature of hypothesis. Hypothesis is defined as “a plausible explanation for an observed phenomenon that can predict what will happen in a given situation” in the previous text. Here it suggested that such explanation is based on existing theoretical understandings or specific model, which is more associated with external non-empirical prior knowledge rather than empirical data. No explicit message about inferential process.
Framework-27(p. 68) E Asking students to demonstrate their own	3	2	2	Both observations and models can serve as the basis for developing explanation. That seems to suggest that both empirical

understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur				evidence and non-empirical information from either first-hand or second-hand sources can be drawn on when students are trying to explain something. Also the sentence after that suggested that explanations "give their inherent appeals to simplicity, analogy, and empirical data", so non-empirical analogies is an acceptable source for explanation construction.
Framework-28(p. 68) E Deciding on the best explanation is a matter of argument that is resolved by how well any given explanation fits with all available data, how much it simplifies what would seem to be complex, and whether it produces a sense of understanding.	1	2	1	Evaluating explanations is a matter of examining how well it fits with data, and this statement imply that different explanations may fit with the same data, which can be seen as mentioning the inferential process. "All available data" seems to point at both first and second-hand information.
Framework-29(p.68) E Because scientists achieve their own understanding by building theories and theory-based explanations with the aid of models and representations and by drawing on data and evidence, students should also develop some facility in constructing model- or evidence-based explanations.	3	2	2	Again, it describes theory and explanation as building on "models and representations" as well as "data and evidence," indicating the inclusion of empirical and non-empirical information from different sources. Students should be encouraged to do both. There is no clear message about the inferential process.
Framework-30(p.69) E Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence	3	2	2	Here it talks about the goal of explanation construction practice. Similar reasons as above.
Framework-31(p.69) E	3	2	2	Here it talks about the goal of explanation

Use primary or secondary scientific evidence and models to support or refute an explanatory account of a phenomenon.				evaluation. Similar reasons as above and with specification that evidence can be "primary or secondary."
Framework-32 (p.69) E They should be encouraged to develop explanations of what they observe when conducting their own investigations and to evaluate their own and others' explanations for consistency with the evidence.	1	1	1	Here it talks about the start of progression. Students are supposed to evaluate explanations in their own investigations based on consistency with evidence, which, in the context should refer to what they get from first-hand empirical investigation. It is followed by an example of owl pellet, in which the explanation is "based on inferences made from what they find" from the dissection.
Framework-33 (p.70) E For example, in investigating the conditions under which plants grow fastest, they may notice that the plants die when kept in the dark and seek to develop an explanation for this finding. Although the explanation at this level may be as simple as "plants die in the dark because they need light in order to live and grow," it provides a basis for further questions and deeper understanding of how plants utilize light that can be developed in later grades.	1	1	1	This is an example illustrating the middle level of progression in explanation construction. It shows how evidence can be inferred from the first-hand empirical, qualitative observation.
Framework-34 (p.70) E On the basis of comparison of their explanation with their observations, students can appreciate that an explanation such as "plants need light to grow" fails to explain why they die when no water is provided. They should be encouraged to	1	1	2	The second part of the example is about evaluation of explanation, again it is challenging the initial explanation using a piece of new, first-hand empirical data. There is no indication of inferential process.

revisit their initial ideas and produce more complete explanations that account for more of their observations				
Framework-35(p. 70) E By the middle grades, students recognize that many of the explanations of science rely on models or representations of entities that are too small to see or too large to visualize. For example, explaining why the temperature of water does not increase beyond 100°C when heated requires students to envisage water as consisting of microscopic particles and that the energy provided by heating can allow fast-moving particles to escape despite the force of attraction holding the particles together.	2	4	2	For middle grades, the description of progression in explanation construction offered an emphasis on model-based explanation accompanied by an example of how the particle model can be used to explain a phenomenon. It does not specify the source of knowledge regarding the particle model and there is no reference to the inferential process.
Framework-36(p. 71) A Their arguments can be based on deductions from premises, on inductive generalizations of existing patterns, or on inferences about the best possible explanation.	3	2	1	This is a general description of arguments in science. It can be based on deduction from premise (infer from non-empirical prior knowledge) and induction of existing patterns (infer from empirical data) and inference about the best possible explanations (infer from explanation).
Framework-37(p. 71) A Over time, ideas that survive critical examination even in the light of new data attain consensual acceptance in the community, and by this process of discourse and argument science maintains its objectivity and progress	1	4	2	This is about evaluation of ideas. The focus is on examining the ideas against "new data" (empirical), without specifying sources and inferential process
Framework-38(p.72) A	1	4	2	This is about goal for argumentation at

Construct a scientific argument showing how data support a claim				grade 12. The focus is on the support of empirical data, without specifying sources and inferential process.
Framework-39(p.72) A Identify possible weaknesses in scientific arguments, appropriate to the students' level of knowledge, and discuss them using reasoning and evidence.	4	4	2	This is about goal for argument evaluation at grade 12. It is unclear what counts as evidence in the contexts. No mention of the source or inferential process.
Framework-40(p.73) A Recognize that the major features of scientific arguments are claims, data, and reasons and distinguish these elements in examples.	1	4	2	This is about goal for argumentation at grade 12. The focus is on the support of (empirical) data, without specifying sources and inferential process.
Framework-41(p.73) A In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose.	1	4	1	This is about the general direction of progression of argumentation practice. Students should "defend their interpretation of the associated data" seems to show a focus on empirical data and inference, yet there is no message about source.
Framework-42 (p.73) A Young students can begin by constructing an argument for their own interpretation of the phenomena they observe and of any data they collect. They need instructional support to go beyond simply making claims—that is, to include reasons or references to evidence and to begin to distinguish evidence from opinion.	1	1	1	This is a description of progression for young students. It focuses on arguments based on inference from first-hand empirical data.
Framework-43 (p.73) A As they grow in their ability to construct scientific arguments, students can draw on a wider range of	4	4	1	This is a description of progression for older students. It suggests that a wider range of evidence can be drawn on, but it is unclear what that means in terms of evidence nature and sources. "Discern

reasons or evidence, so that their arguments become more sophisticated. In addition, they should be expected to discern what aspects of the evidence are potentially significant for supporting or refuting a particular argument.				which aspects of evidence are potentially significant" seems to imply a process of inferring
Framework-44 (p.74) A As they become more adept at arguing and critiquing, they should be introduced to the language needed to talk about argument, such as claim, reason, data, etc.	1	4	2	Similar to framework-35
Framework-45 (p.74) A Exploration of historical episodes in science can provide opportunities for students to identify the ideas, evidence, and arguments of professional scientists.	4	4	2	It is unclear what can count as evidence in this process. There is no mention of the inferential process.
Framework-46(p. 75) C Being a critical consumer of science and the products of engineering, whether as a lay citizen or a practicing scientist or an engineer, also requires the ability to read or view reports about science in the press or on the Internet and to recognize the salient science, identify sources of error and methodological flaws, and distinguish observations from inferences, arguments from explanations, and claims from evidence.	4	4	2	It is unclear what count as evidence in "discern claim from evidence", and there is no mention of the inferential process.
Framework-47(p.79) G Procedural knowledge has also been called "concepts	1	4	2	Procedural knowledge seems to refer to "an understanding of the importance and appropriate use of controls, double-blind

of evidence"				trials, and other procedures (such as methods to reduce error)" in the previous text, which are empirical design approaches. Evidence here therefore refers to empirical data And the use of these techniques implies certain assumptions about how inference can be made later?
Framework-48 (p. 79) G Ideas often survive because they are coherent with what is already known, and they either explain the unexplained, explain more observations, or explain in a simpler and more elegant manner.	3	2	2	Ideas "survive" for both empirical (explain more observations) reason and non-empirical (coherent with what is already known) reason. All kinds of information sources can be involved in such judgement. "coherent with" seems to indicate the inferential process.
Framework-49(p.79) G Engagement in modeling and in critical and evidence-based argumentation invites and encourages students to reflect on the status of their own knowledge and their understanding of how science works.	4	4	2	It is unclear what "evidence" mean in this context, and there is no mention of the inferential process.
NGSS-1(p.51) Q Ask and/or identify questions that can be answered by an investigation.	1	1	2	The K-2 expectation on asking questions. Here the answer to the question should come directly from first-hand empirical investigation. No mention of inferredness.
NGSS-2(p.51) Q Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships	4	4	2	The 3-5 expectation on asking questions. Here the answer to the question should come from empirical investigation, but the prediction comes from patterns such as cause and effect relationships, which can come from prior knowledge or inferred from empirical data. The nature and sources are unclear.
NGSS-3(p.51) Q (Ask questions) to identify and/or clarify evidence and/or the premise(s) of an argument	4	4	2	The 6-8 expectation on asking questions. It can refer to questions looking for empirical evidence or other supports. It is not quite clear about the nature and sources of evidence that should be identified or clarified when answering such question.

				No mention of inferredness.
NGSS-4(P.51) Q Ask question: that require sufficient and appropriate empirical evidence to answer	1	4	2	The 6-8 expectation on asking questions. Clearly this is about forming an answer based on empirical evidence, yet it is not clear whether it has to be first-hand. No concern about inferential process.
NGSS-5(P. 51) Q when appropriate, frame a hypothesis based on observations and scientific principles	3	2	2	The 6-8 expectation on asking questions. It is clear here first-hand, empirical data such as observations and non-empirical, second-hand scientific principles can both play the supporting role.
NGSS-6(P. 51) Q Ask questions: that challenge the premise(s) of an argument or the interpretation of a data set.	3	4	1	The 6-8 expectation on asking questions. Premise (s) are most likely theoretical understandings or prior knowledge. Locating non-empirical premise and interpretation of data, which indicates inferential process, as what to challenge seem to indicate that both can support an argument. This is no clear message about the acceptable sources.
NGSS-7(P.51) Q Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions	1	4	2	The 9-12 expectation on asking questions. Here the focus is on “empirically testable questions,” indicating an emphasis of first-hand, empirical data. No clear mention of inferredness.
NGSS-8(P.51) Q Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design	3	2	1	The 9-12 expectation on asking questions. Alike NGSS-5, when it comes to asking questions that challenge arguments, the concern will extend beyond empirical data to include non-empirical premise. “Interpretation of a data set” clearly mentioned inferredness.
NGSS-9(P.52) Q Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation.	1	2	2	It is quite clear that “scientific questions” need to be answered by explanation supported by empirical evidence. The source is not confined and the inferredness is not mentioned.

NGSS-10(P.52) M As such, models are based on evidence. When new evidence is uncovered that the models cannot explain, models are modified.	1	4	2	This is a general description of the process of modeling. In previous texts, it suggests that students can "refine models through an iterative cycle of comparing their predictions with the real world and then adjusting them to gain insights into the phenomenon being modeled." Here the evidence should refer to "the real world," which is another way of saying empirical. There is no confinement about source and no mention of the inferential process.
NGSS-11(P. 53) M Develop a simple model based on evidence to represent a proposed object or tool.	4	4	2	K-2 expectation on modeling. Not quite sure what evidence refers to here. No mention of the inferential process.
NGSS-12(P.53) M Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events	4	4	2	3-5 expectation on modeling. Evidence that shows the relationship among variables can be prior knowledge (e.g., mom told me eating French fries can make me fat) or empirical data. There is no confinement about source and no mention of the inferential process.
NGSS-13(P.53) M Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed.	4	4	2	6-8 expectation on modeling. Here the evidence should be about what happens if a variable or a component of a system is changed. This again, can be empirical or non-empirical. No mention of sources or inferredness
NGSS-14(P.53) M Develop and/or use a model to generate data to test ideas about phenomena in natural or designed	1	1	2	Here model is the tool the students should use to generate first-hand empirical data. No mention of inferential process.
NGSS-15(p. 53) M Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.	4	4	2	No clear clue for what evidence refers to in that sentence. No mention of the inferential process.

NGSS-16(p. 53)M Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	4	4	2	Same as above
NGSS-17(p. 53)M Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/ or solve problems.	1	1	2	Same as NGSS-13
NGSS-18(P.54)I Whether students are doing science or engineering, it is always important for them to state the goal of an investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions. Students should design investigations that generate data to provide evidence to support claims they make about phenomena. Data are not evidence until used in the process of supporting a claim. Students should use reasoning and scientific ideas, principles, and theories to show why data can be considered evidence.	1	1	1	This is describing the practice of planning and conducting investigation. It is focusing on getting empirical evidence from first hand investigation. It clearly stated that the data are not evidence until inferred based on reasoning and scientific ideas.
NGSS-19(p.55) I Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and	1	1	2	This is the k-2 expectation on planning and carrying out investigation. The emphasis is on first-hand generation of empirical data that supports explanations. It does not refer to inferential process

progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.				
NGSS-20(P. 55) I Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	1	1	1	Similar as above, but data “serve as the basis for evidence” seems to refer to the inferential process
NGSS-21(P. 55) I Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.	1	2	2	“First hand or from media” seems to suggest that both first-hand or second-hand information can be used. Observation/ measurement confine it to empirical. No mention of the inferredness.
NGSS-22(P. 55) I Make predictions based on prior experiences.	3	3	2	This is the k-2 expectation on planning and carrying out investigation. Here the predictions are the “ideas” and prior experience is the supporting information. Prior experience seems to be very inclusive, it can be everyday experience or in school investigative experience, covering empirical or non-empirical information. It is second-hand as it is what students bring to classroom. No explicit mention of inferredness.
NGSS-23(P. 55) I Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions	1	1	2	This is the 3-5 expectation on planning and carrying out investigation. It bears similarity to the k-2 expectation, but use “control variables” instead of “fair test”, and “evidence” instead of “data”. It is hard to guess what difference that makes.
NGSS-24(P. 55) I Plan and conduct an investigation	1	1	1	This is the 3-5 expectation on planning and carrying out investigation. Similar to NGSS-19, only with an emphasis on

collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials is considered.				controlling variables. "Serve as basis" indicates inferential process.
NGSS-25(P. 55) I Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or to test a design solution	1	1	1	This is the 3-5 expectation on planning and carrying out investigation. The emphasis is on collecting first-hand empirical data to "serve as the basis for evidence" to explanation.
NGSS-26(P. 55) I Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.	1	1	2	This is the 6-8 expectation on planning and carrying out investigation. It is similar to NGSS-22, only with emphasis on use multiple variables. No mention of the inferential process.
NGSS-27(P. 55) I Plan an investigation individually and collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	1	1	2	This is the 6-8 expectation on planning and carrying out investigation. Here the emphasis is on planning, but in terms of getting information to support ideas, the emphasis is on estimating how much empirical data one should get from first-hand investigation to support claim. No mention of the inferential process.
NGSS-28(P. 55) I Conduct an investigation and/ or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	1	1	1	This is the 6-8 expectation on planning and carrying out investigation. Similar to NGSS-24, referring to the inferential process through data "serve as the basis for evidence"
NGSS-29(P. 55) I Collect data to produce data	1	1	1	Similar to the one above, only "answer" to scientific questions would embrace a wider

to serve as the basis for evidence to answer scientific questions or to test design solutions under a range of conditions.				range of ideas.
NGSS-30(P. 55) I Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models	1	1	2	This is the 9-12 expectation on planning and carrying out investigation. The emphasis is similar to that of other grade bands, only with the focus on models as the ideas. No mention of the inferential process.
NGSS-31(P. 55) I Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems.	1	1	2	Similar to NGSS-26
NGSS-32(P. 55) I Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	1	1	1	This is the 9-12 expectation on planning and carrying out investigation. It concerns “produce data to serve as the basis for evidence,” showing the emphasis on inferring evidence from first-hand empirical data.
NGSS-33(P. 56) An Because raw data as such have little meaning, a major practice of scientists is to	1	4	1	This is general description of the practice of analyzing empirical data. It did not confine the source of data, and since analysis “bring out the meaning of data”, it

organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence				is clearly an inferential process.
NGSS-34(P. 56) An Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error.	1	4	1	"interpreting data" apparently refers to the inferential process used with empirical data. No confinement for the sources
NGSS-35(P. 56) An Whether analyzing data for the purpose of science or engineering, it is important that students present data as evidence to support their conclusions.	1	4	1	"present data as evidence" seems to refer to the inferential process. No confinement about the source.
NGSS-36(P. 57) An Use observations (firsthand or from media) to describe patterns and/ or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems	1	2	1	This is k-2 expectation on analyzing data. The emphasis is on "use observation" to describe patterns or relationships, and then use those to "answer scientific questions". An inferential process is involved. "firsthand or from media" define the sources as "both".
NGSS-37(P. 57) An Represent data in tables and/ or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships	1	4	1	This is 3-5 expectation on analyzing data. "reveal" and "indicate" refers to the inferential process. No confinement on the sources of data
NGSS-38(P. 57) An Analyze and interpret data to make sense of	1	4	1	This is 3-5 expectation on analyzing empirical data. "Interpret" indicates the inferential process. No confinement on the

phenomena, using logical reasoning, mathematics, and/or computation.				sources of data
NGSS-39(P. 57) An Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and non-linear relationships.	1	2	1	This is 6-8 expectation on analyzing empirical data. “Construct, analyze, and/or interpret” and “identify” indicates the inferential process Large dataset seems to refer to second-hand data.
NGSS-40(P. 57) An Analyze and interpret data to provide evidence for phenomena	1	4	1	This is 6-8 expectation on analyzing data. “Interpret data to provide evidence” indicates the inferential process. No confinement on the sources. What is evidence for phenomena?
NGSS-41(P. 57)An Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	1	4	1	This is 9-12 expectation on analyzing empirical data. Analyze data using tools to make claims seems to indicate the inferential process. Although model is mentioned here, it is mostly “computational and mathematical” models such as statistical models, and its role is not to support claim but as tools for getting evidence from the data (inferredness).
NGSS-42(P. 57)An Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.	1	4	2	This is 9-12 expectation on analyzing empirical data. The emphasis is on evaluating the explanation in light of new data. No confinement for sources of data and no mention of the inferential process.
NGSS-43(P. 59)Ma Use counting and numbers to identify and describe patterns in the natural and designed world(s).	1	4	1	This is K-2 expectation on math and computational thinking, emphasizing inferring patterns from quantitative data. No mention of inferredness.
NGSS-44(P. 59)Ma Organize simple data sets to reveal patterns that suggest relationships.	1	4	1	This is 3-5 expectation on math and computational thinking. “Reveal” indicates the inferential process of getting from data-set to pattern. No confinement on sources.
NGSS-45(P. 59)Ma Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses	3	2	1	This is 6-8 expectation on math and computational thinking. “Identify patterns in datasets” refers to the process of inferring from empirical data. Math concepts count as second-hand non-

to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments				empirical information.
NGSS-46(P. 59) Ma Use mathematical representations to describe and/or support scientific conclusions and design solutions	1	4	1	This is 9-12 expectation on math and computational thinking. Math representation should be understood as short for math representation of (empirical) data? No confinement on sources.
NGSS-47(P. 59) Ma Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world	4	4	1	This is 9-12 expectation on math and computational thinking. The information for evaluation is gained through comparing the outcome of limit cases in modeling with what is known about the real world, which is not necessarily empirical. "Mathematical expressions, computer programs, algorithms, or simulations of a process or system" serve as the ideas to be tested.
NGSS-48(P. 60) E A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. (NRC, 2012, p. 52)	1	2	1	This is a general description of how theory is evaluated. It is really weird since it cites the Framework, yet the text back in the framework is "A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence and parsimony," which did not clearly suggest what should be used as the information for evaluation, leaving alone its being "empirical evidence". "Greater explanatory power" seems to indicate the inferential process.
NGSS-49(P. 60) E An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question,	1	4	2	This is a general description of explanation. It is described as more of a pattern between variables supported by empirical data. It does not confine the sources or mention the inferential process.

scientists often design investigations to generate data.				
NGSS-50(P. 60) E Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur.	3	2	2	This is a quote from the framework (see framework-25), but strangely, it is quoted as a description of "design a solution"
NGSS-51(P. 61) E Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.	3	4	2	This is the k-2 expectation on constructing explanation. "use of evidence and idea in constructing evidence-based accounts" seem to suggest both empirical and non-empirical information can be used. No confinement of sources and no mention of the inferential process.
NGSS-52(P. 61) E Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	1	2	2	This is the k-2 expectation on constructing explanation. Observations suggests empirical nature, "firsthand or from media" define the sources. No mention of the inferential process.
NGSS-53(P. 61) E Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in	4	4	2	This is the 3-5 expectation on constructing explanation. Similar to NGSS-48, but here it only emphasizes the use of evidence, and it is unclear what is included in evidence

designing multiple solutions to design problems.				
NGSS-54(P. 61) E Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	1	4	2	This is the 3-5 expectation on constructing explanation. The examples of evidence seem to point at empirical data. No confinement of sources. No clear mention of inferential process.
NGSS-55(P. 61) E Identify the evidence that supports particular points in an explanation.	4	4	2	This is the 3-5 expectation on constructing explanation. It is unclear what evidence mean in the contexts. No mention of inferential process.
NGSS-56(P. 61) E Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	4	2	2	This is the 6-8 expectation on constructing explanation. It is similar to NGSS-48 and NGSS-50. The emphasis is on multiple sources of evidence, yet still there is no clear clue for what evidence refers to. The evidence should be consistent with ideas and theories. But this prior knowledge did not play the supporting role directly.
NGSS-57(P. 61) E Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	3	2	2	This is the 6-8 expectation on constructing explanation. Here it is clear that evidence from various sources and non-empirical information (assumption and theories) can be used to support explanation construction. No clear mention of inferredness.
NGSS-58(P. 61) E Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena,	3	2	2	This is the 6-8 expectation on constructing explanation. Similar to the one above.

examples, or events.				
NGSS-59(P. 61) E Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.	4	2	2	This is the 9-12 expectation on constructing explanation. The evidence should be from “multiple and independent student-generated sources of evidence”, which seems to suggest that both first- and second-hand sources are acceptable. yet it is unclear whether it needs to be empirical. No mention of the inferential process
NGSS-60(P. 61) E Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future	3	2	2	This is the 9-12 expectation on constructing explanation. The variety of sources and nature of the supporting information has been explicitly stated. No mention of the inferential process.
NGSS-61(P. 61) E Apply scientific ideas, principles, and/ or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects	3	2	2	Similar as above
NGSS-62(P. 61) E Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion	4	4	2	Here theories and models clearly play the role of reasoning, and it is unclear what evidence refers to. No mention of the inferential process.
NGSS-63(P. 61) A	1	4	1	Cited from framework (see framework-

In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose.				37), Interpretation of the associated data seems to refer the inferential process of construction evidence from empirical data
NGSS-64(P. 61) A In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon.	4	4	2	It is unclear what evidence refers to. No mention of inferential process.
NGSS-65(P. 61) A As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community	4	4	2	It is unclear what evidence refers to. No mention of inferential process.
NGSS-66(P. 61) A Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.	4	4	2	General description of how argument should be used in multiple activities, yet it is not clear what argument involves and the meaning of evidence is not clear either. No mention of inferential process.
NGSS-67(P. 62) A Identify arguments that are supported by evidence	4	4	2	This is k-2 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-68(P. 62) A Distinguish between explanations that account for all gathered evidence and those that do not	4	4	2	This is k-2 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-69(P. 62) A Listen actively to arguments to indicate agreement or disagreement based on	4	4	2	This is k-2 expectation on argumentation. Use evidence to evaluate, yet It is unclear what evidence refers to. No mention of inferential process.

evidence, and/or to retell the main points of the argument				
NGSS-70 (P. 62) A Construct an argument with evidence to support a claim.	4	4	2	This is k-2 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-71 (P. 62) A Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).	4	4	2	This is 3-5 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-72 (P. 62) A Compare and refine arguments based on an evaluation of the evidence presented	4	4	2	This is 3-5 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-73 (P. 62) A Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.	4	4	2	This is 3-5 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-74 (P. 62) A Construct and/or support an argument with evidence, data, and/or a model.	3	4	2	This is 3-5 expectation on argumentation. It is unclear what evidence refers to, but model seems to imply that non-empirical ideas can be used. No mention of inferential process.
NGSS-75 (P. 62) A Use data to evaluate claims about cause and effect.	1	4	2	This is 3-5 expectation on argumentation. “Data” should be referring to empirical data? No confinement on sources and no mention of inferredness.
NGSS-76 (P. 62) A Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or	4	4	2	This is 6-8 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.

solutions about the natural and designed world(s).				
NGSS-77 (P. 62) A Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts	4	4	1	This is 6-8 expectation on argumentation. It is unclear what evidence refers to. “Interpretations of facts” seems to emphasize the inferential process
NGSS-78 (P. 62) A Respectfully provide and receive critiques about one’s explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	4	4	2	This is 6-8 expectation on argumentation. The emphasis is on criticizing by using evidence but it is unclear what evidence refers to. No mention of inferential process.
NGSS-79 (P. 62) A Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	3	2	2	This is 6-8 expectation on argumentation. Here argument should be supported by empirical evidence and scientific reasoning. It is unclear what evidence refers to, but scientific reasoning should include second-hand non-empirical information (e.g., analogical reasoning) ? No mention of inferential process.
NGSS-80(P. 62) A Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science	3	2	2	This is 9-12 expectation on argumentation. Here argument should be supported by evidence and scientific reasoning. It is unclear what evidence refers to, but scientific reasoning should include non-empirical information from second-hand sources (e.g., analogical reasoning)? No mention of inferential process.

NGSS-81(P. 62) A Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., tradeoffs), constraints, and ethical issues	3	2	2	This is 9-12 expectation on argumentation. It is unclear what evidence refers to. But arguments are supposed to be evaluated based on accepted explanations, which should include non-empirical information. No clear confinement on sources. No mention of the inferential process.
NGSS-82(P. 62) A Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	4	4	2	This is 9-12 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-83(P. 62) A Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions	4	4	2	This is 9-12 expectation on argumentation. It is unclear what evidence refers to. And “probing reasoning and evidence” seems to imply that both are supporting information?
NGSS-84(P. 62) A Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence	4	4	2	This is 9-12 expectation on argumentation. While data should refer to empirical data, it is unclear what evidence refers to. No mention of the inferential process.
NGSS-85(P. 62) A Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student generated evidence.	4	4	2	This is 9-12 expectation on argumentation. It is unclear what evidence refers to. No mention of inferential process.
NGSS-86(P. 62) C Being a critical consumer of	4	4	1	Distinguish observation from inference addresses the inferential process. It is

information about science and engineering requires the ability to read or view reports of scientific or technological advances or applications (whether found in the press, on the Internet, or in a town meeting) and to recognize the salient ideas, identify sources of errors and methodological flaws, and distinguish observations from inferences, arguments from explanations, and claims from evidence.				unclear what evidence refers to.
NGSS-87(P. 62) C Communicating information, evidence, and ideas can be done in multiple ways: using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions.	4	4	2	This is general description on communication. It is unclear what evidence refers to. No mention of inferential process.
NGSS-88(P. 62) C Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).	4	3	2	This is k-2 expectation for communication. The source is clearly second-hand. It is unclear whether it has to be empirical. No mention of the inferential process.
NGSS-89(P. 62) C Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or	4	3	2	This is k-2 expectation for communication. The sources exemplified are second hand information, either empirical or non-empirical. No mention of the inferential process.

supporting a scientific claim.				
NGSS-90(P. 62) C Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.	4	3	2	This is 3-5 expectation for communication. Scientific ideas from the texts or media are second hand information. It is unclear what evidence refers to. No mention of the inferential process.
NGSS-91(P. 62) C Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	4	3	2	This is 6-8 expectation for communication. Reading indicates second-hand. It is not clear what evidence refers to. No mention of the inferential process.
NGSS-92(P. 62) C Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence	4	4	2	This is 6-8 expectation for communication. It is about evidence evaluation but not clear what evidence is. It suggests that “multiple appropriate sources” can be drawn on, but it is not clear whether that includes both first and second-hand sources.
NGSS-93(P. 62) C Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate	4	3	2	This is 9-12 expectation for communication. It is from second-hand sources, but it is not clear what evidence is. No mention of the inferential process.

terms.				
NGSS-94(P. 62) C Gather, read, and evaluate scientific and/ or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source	4	3	2	This is 9-12 expectation for communication. It is on evidence evaluation but it is not clear what evidence is. No mention of the inferential process.