Differentiating Theory and Law

Some students are talking after their science class. Some of what they say is incorrect. Read each conversation below. Then, follow the instructions.

**Conversation 1**

These students have a misconception about the *definition* of a scientific *[theory/law]*.

Student 1: *“[Insert 1st student’s statement.]”*

Student 2: *“[Insert 2nd student’s statement.]*”

Help the students understand why scientific *[theories/laws] [insert correction of students’ misconception]* by answering the following:

1. Describe two characteristics of scientific *[theories/laws]*.
2. Give an example of a scientific *[theory/law]* and explain how it has two characteristics of scientific *[theories/laws]*.
3. Use your example *[theory/law]* to explain why scientific *[theories/laws] [insert correction of students’ misconception]*.

**Conversation 2**

These students have a misconception about the *similarities and differences* between scientific theories and scientific laws.

Student 1: *“[Insert 1st student’s statement.]”*

Student 2: *“[Insert 2nd student’s statement.]”*

Help the students understand why *[insert correction of students’ misconception]* by answering the following:

1. Describe two ways in which scientific theories and scientific laws are **similar**.
2. Describe two ways in which scientific theories and scientific laws are **different**.
3. Give an example of a scientific theory and scientific law. Use your examples to explain why *[insert correction of students’ misconception]*.

**Conversation 3**

These students share a misconception about the *application* of scientific *[theories/laws]*.

Student 1: *“[Insert 1st student’s statement.]”*

Student 2: *“[Insert 2nd student’s statement.]”*

Help the students understand why scientific *[theories/laws] [insert correction of students’ misconception]* by answering the following:

1. Describe two ways in which all scientific *[theories/laws]* can be applied in general.
2. Give a specific example of how a scientific *[theory/law]* has been or could be applied. Use your example to explain why scientific *[theories/laws] [insert correction of students’ misconception]*.

**Conversation 4**

These students share a misconception about the *development* of scientific *[theories/laws]*.

Student 1: *“[Insert 1st student’s statement.]”*

Student 2: *“[Insert 2nd student’s statement.]*”

Help the students understand why scientific *[theories/laws] [insert correction of students’ misconception]* by answering the following:

1. Describe two things scientists do, or might do, to develop a scientific *[theory/law]*.
2. Describe two things scientists did, or might have done, to develop a particular scientific *[theory/law]*.
3. Explain why scientific *[theories/laws] [insert correction of students’ misconception]*.

Scoring Plan

**Note**: Credit for scoring items within a conversation is awarded if scoring criteria are met by any part of the response to that conversation.

**Conversation 1: Definition of Theory or Law**

**Definition Characteristics**

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| Student describes one or more characteristics of a scientific *[theory/law]*.  Examples for a theory context:  *These responses would receive credit:*   * *Theories are based on inferences from data.* * *Theories explain a broad range of observations.* * *Theories have never been disproved.*   *These responses would not receive credit:*   * *Theories are used in science to describe the relationships between variables in nature.* (This statement describes scientific laws.) * *Theories are used by science.* (This statement is too vague to be meaningful.) * *Theories have been proved*. (This statement is incorrect because science is always tentative—theories may eventually be disproven.)   Examples for a law context:  *These responses would receive credit:*   * *Laws are formed from a large amount of observations.* * *Laws describe a relationship between phenomena.* * *Laws have never been disproved.*   *These responses would not receive credit:*   * *Laws are not explanations of what causes things to happen in nature.* (This information is already given to the student and adds no new information.) * *Laws are used by science.* (This statement is too vague to be meaningful.) * *Laws have been proved.* (This statement is incorrect because science is always tentative—laws may eventually be disproved.) | 1 pt. |
| Student describes two or more characteristics of a scientific *[theory/law]*. | 1 pt. |

Scoring Plan (continued)

**Illustration of Definition**

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| Student provides an example of a scientific *[theory/law]* ***and*** describes how it has one or more of the characteristics of scientific *[theories/laws]*.  Examples for a theory context:  *These responses would receive credit:*   * *The theory of evolution explains many observations from biology and geology.* * *The big bang theory was formed as information from space was gathered and scientists started to debate its meaning.*   *These responses would not receive credit:*   * *The theory of evolution does that.* (“That” refers to the student’s previous explanation of the definition of theories. This statement does not explain how the example theory has the characteristics of theories described.) * *The theory of evolution is used by scientists.* (This statement is too vague to be meaningful).   Examples for a law context:  *These responses would receive credit:*   * *The law of gravity is based on many scientific observations.* * *The law of conservation of mass describes how matter behaves together.*   *These responses would not receive credit:*   * *The law of gravity does that.* (“That” refers to the student’s previous explanation of the definition of laws. This statement does not explain how the example law has the characteristics of laws described.) * *The law of conservation of mass is useful.* (This statement is too vague to be meaningful.)   *Student does not have to provide the standard scientific name of the [theory/law] if the [theory/law] can be inferred from the student’s response.* | 1 pt. |
| Student provides an example of a scientific *[theory/law]* ***and*** describes how it has two or more of the characteristics of scientific *[theories/laws].*  *Student may use the same or a different example of a scientific [theory/law] to describe a second characteristic; the second characteristic described must be unique to receive credit.* | 1 pt. |

**Misconception Rectification**

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| Student provides details related to his or her example *[theory/law]* that rectify the misconception that *[insert misconception]*.  *Student does not have to provide the standard scientific name of the [theory/law] if the [theory/law] can be inferred from the student’s response.*  *Point is awarded if student rectifies the misconception but does not specifically reference the misconception.* | 2 pts. |

Scoring Plan (continued)

**Conversation 2: Relationships between Theories and Laws**

**Similarities between Theories and Laws**

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| Student describes one or more similarities between theories and laws.  Examples:  *These responses would receive credit:*   * *Both theories and laws are based on scientific observation and examination.* * *Both theories and laws are used by science to predict new phenomena.*   *These responses would not receive credit:*   * *Both theories and laws are used by scientists.* (This statement is too vague to be meaningful.) * *Both theories and laws have to do with natural phenomena.* (This statement is too vague to be meaningful.) * *Both theories and laws involve reasoning.* (This statement is too vague to be meaningful.) | 1 pt. |
| Student describes two or more similarities between theories and laws. | 1 pt. |

**Differences between Theories and Laws**

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| Student describes one or more differences between theories and laws.  Examples:  *These responses would receive credit:*   * *Laws are used to describe phenomena, and theories are used to explain phenomena.* * *Theories are often based on indirect evidence, while laws are often based on direct evidence.*   *These responses would not receive credit:*   * *We can be more confident of laws than we can of theories.* (This is not always true.) * *Theories can change over time, but laws remain the same.* (Both theories and laws are subject to revision.) | 1 pt. |
| Student describes two or more differences between theories and laws. | 1 pt. |

**Misconception Rectification**

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| Student provides details related to an example of a scientific theory or law that rectify the misconception that *[insert misconception]*.  *Student does not have to provide the standard scientific name of the theory or law if the theory or law can be inferred from the student’s response.*  *Point is awarded if student rectifies the misconception but does not specifically reference the misconception.* | 2 pts. |

Scoring Plan (continued)

**Conversation 3: Application**

**Scientific Application**

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| Student describes one or more applications of scientific *[theories/laws]* in general.  Examples for a theory context:  *These responses would receive credit:*   * *Theories are used by scientists to help make predictions and control outcomes.* * *Theories are used to explain phenomena.*   *These responses would not receive credit:*   * *Scientists use theories to talk about natural phenomena.* (This statement is too vague to be meaningful.) * *Scientists use theories to do science.* (This statement is too vague to be meaningful.)   Examples for a law context:  *These responses would receive credit:*   * *Scientists use laws to help make predictions and control outcomes.* * *Scientists use laws to describe phenomena.*   *These responses would not receive credit:*   * *Scientists use laws to talk about nature.* (This statement is too vague to be meaningful.) * *Scientists use laws to do science.* (This statement is too vague to be meaningful.) | 1 pt. |
| Student describes two or more applications of scientific *[theories/laws]* in general. | 1 pt. |

**Misconception Rectification**

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| Student provides a specific example of how a scientific *[theory/law]* has been or could be applied that rectifies the misconception that *[insert misconception]*.  *Student does not have to provide the standard scientific name of the [theory/law] if the [theory/law] can be inferred from the student’s response.*  *Point is awarded if student rectifies the misconception but does not specifically reference the misconception.* | 2 pts. |

Scoring Plan (continued)

**Conversation 4: Development**

**Developmental Stages**

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| Student describes one or more stages of the development of scientific *[theories/laws]*.  Examples for a theory context:  *These responses would receive credit:*   * *Scientists gather data before developing theories.* * *Scientists make inferences about data to create theories.*   *These responses would not receive credit:*   * *Scientists use a very thorough process to create theories.* (This statement is too vague to be meaningful.) * *There are many steps in the process of developing theories.* (This statement is too vague to be meaningful.) * *A theory can eventually be disproved.* (This is not a stage of development of scientific theories because it would cease to be a theory if disproved.)   Examples for a law context:  *These responses would receive credit:*   * *Scientists gather data before making laws.* * *Scientists make inferences about data to create laws.*   *These responses would not receive credit:*   * *Scientists use a very thorough process to create laws.* (This statement is too vague to be meaningful.) * *There are many steps in the process of making a law.* (This statement is too vague to be meaningful.) * *A law can eventually be disproved.* (This is not a stage of development of scientific laws because it would cease to be a law if disproved.) | 1 pt. |
| Student describes two or more stages of the development of scientific *[theories/laws]*. | 1 pt. |

Scoring Plan (continued)

**Illustration of Developmental Stages**

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| Student provides an example of one or more stages of how a particular scientific *[theory/law]* has been or could be developed.  Examples for a theory context:  *These responses would receive credit:*   * *The theory of evolution was formed after observing the traits and distribution of many different organisms.* * *The atomic theory has been further refined as our understanding of subatomic particles has improved.*   *These responses would not receive credit:*   * *Scientists formed the theory of evolution over time.* (This statement is too vague to be meaningful.) * *Atomic theory has been further refined over time.* (This statement is too vague to be meaningful.)   Examples for a law context:  *These responses would receive credit:*   * *The law of gravity was formed after observing the behavior of many different objects and the planets.* * *The law of conservation of mass has been refined as our understanding that mass can turn into energy has improved.*   *These responses would not receive credit:*   * *The law of gravity was formed after scientists made many observations.* (This statement could be made concerning any law and does not illustrate the stage of *observation* specific to the law of gravity.) * *It was a long process to form the law of conservation of energy.* (This statement is too vague to be meaningful.)   *Student does not have to provide the standard scientific name of the [theory/law] if the [theory/law] can be inferred from the student’s response.* | 1 pt. |
| Student provides an example of two or more stages of how a particular scientific *[theory/law]* has been or could be developed.  *Student may use the same or a different example of a scientific [theory/law] to describe a second characteristic; the second characteristic described must be unique to receive credit.* | 1 pt. |

**Misconception Rectification**

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| Student explains that scientific *[theories/laws]* *[insert correction of misconception]*.  *Student does not have to provide the standard scientific name of the [theory/law] if the [theory/law] can be inferred from the student’s response.*  *Point is awarded if student rectifies the misconception but does not specifically reference the misconception or a particular scientific [theory/law].* | 2 pts. |