ICOTS-10 Notes

Front Matter

Terms

- *Cognitive transfer* has been used in the learning literature to describe the degree to which knowledge can be successfully applied to new or novel situations (e.g., Singley & Anderson, 1989)
- Introductory Statistics Understanding and Discernment Outcomes (ISTUDIO) Assessment

Goals for the session

1. Introduce ISTUDIO Assessment
2. What was ISTUDIO designed to measure?
3. Share (very) brief outline of the study
4. **What we learn when asking questions like this?**

What was ISTUDIO designed to measure?

Chris Wild said in his talk on Tuesday, that our courses should emphasize students doing the stuff that ***can't*** *be automated... honestly, that's the goal of ISTUDIO in a nutshell*

Slide Text

1. Statistical thinking
   - Wild & Pfannkuch (1999) posed image of Statistical thinking as "shuttling" between problem context and architypical "models"
   - **ISTUDIO attempts to isolate each direction in the shuttling process**
     - context to architype ("backward transfer")
     - architype to context ("forward transfer")
2. Discernment of statistical questions
   - **Reflexively asking and answering "Can statistics help?" is perhaps the first step to productive analysis**
   - Difference between deterministic and stochastic inquiry (Franklin & Garfield, 2006)

BRIEF outline of study

- Fairly large sample of post-secondary students across US
- Convenience Sample of instructors that replied to email solicitations
- 7 **open-ended** tasks, each with two or more parts
- (This part was shared with students)
  - Statistical inference is appropriate for some, but **NOT ALL** questions.
  - Respond as though you are **giving advice/instructions to a classmate** that has asked you for help.
  - Provide enough detail that a classmate could easily carry out your instructions, and explain how he or she should **interpret the result** within the context of the problem.
  - **NO Calculations**
- Scoring
  - Every task has a detailed rubric with real student examplars
  - Rubric development and analysis available in Beckman (2015)

- Leaving psychometric analysis out of scope here, but reported in detail elsewhere

What do we learn when asking questions like this?

Task Description: Note Identification task

Item credit: Garfield, J., delMas, R., & Zieffler, A. (2012)

Key details

- Some people who have a good ear for music can identify the notes they hear when music is played.
- A music teacher choosing and playing a note at random on the piano.

- The student names which note was played without looking.
- **Suppose you want to determine whether a student named Carla has a "good ear for music" using this method of note identification.**

Prompts

- Should statistical inference be used? Explain.
- Explain how you would decide whether Carla has a good ear for music using this method of note identification.

Selected responses to the Note Identification task

1. "Since statistical inferences measure population it would not be a good idea to use this in the case of carla because it is measuring the accuracy of her note identification skills, not measuring a population." (Student 1038)
2. "No, I don't think so because you are not comparing her data to anyone else's data or to an overall population." (Student 1006)
3. "No, because Carla is an individual in the population not a sample" (Student 780)

Observation: Population as a process

- 35 of the 178 students ($\approx 20\%$) said that statistical inference was **NOT** valid because Carla is a single person
  - Some students constructed some kind of artificial discrete/countable population
  - They frequently cited that her result could not represent a population **of other people**
- For example:
  - "I would sample at least less then 10% of the overall population but not just one person." (Student 780)
  - "I would test a population of people on whether they have a good ear for music and then compare the students score compared to the rest of the population." (Student 1550)
- The intuition is reasonable to use a population to establish criterion for "a good ear", but this certainly does not disqualify use of inference

Task Description: Rossman-Chance Task

Item credit: Rossman & Chance (2001)

Prompt

An underlying principle of all statistical inference is that one uses sample statistics to learn something about the unknown population parameters. Demonstrate that you understand this statement by describing a realistic scenario in which you might use a sample statistic to infer something about a population parameter. For the context of your example, clearly identify:

- the research question for your scenario,
- the sample,
- the population,
- the statistic, and
- the parameter.

Be as specific as possible, and do not use any example that was discussed in your statistics course.

Selected responses to Rossman-Chance Task

- Student 1486: *Question: Is facebook a popular social networking site among college students? The **sample** will be 100 randomly selected students from 5 American campuses (500 students total). The **population** will be college students. The **statistic** will be whether or not they use facebook and the **parameter** will be yes or no.*
- Student 1550: *Is there a major difference in test scores of males verse females on their ACT scores? The **sample** is random sample of 500 juniors in [the state]. 250 males. 250 females. **Population**: all juniors in [the state]. **Statistic**: 500 **parameter**: all juniors in [the state].*
- Student 1459: *If you would like to figure out the average height of men aged from 20-35? / Population: Everyone in that age range / Sample: selections made from the population / Statistic: The height from the men / Parameter: The people who are getting tested*

Observation: Lexical ambiguity/misconceptions of parameter

- Students showed a great deal of variability among concepts ascribed to key foundations of inferential statistics
- The task is unique in that it permits students to use a context of their own invention/choosing
- The **parameter** seemed particularly challenging for students, to which they ascribed a variety of concepts (e.g., a variable, a study constraint, a population).
- This is evidence of an issue

Task Description: Display Screen Quality

Key details

- An electronics company makes customized laptop computers for its customers by assembling various parts purchased in bulk from other companies.
- The company purchases bulk orders of 150 display screens from a supplier.
- If more than 5% of the display screens are bad, the company may reject the entire bulk order for a refund.
- **A trained engineer [will] determine if each of the 150 display screens is good or bad before deciding whether to accept or reject the whole order.**

Prompts

- Should statistical inference be used? Explain.
- Explain how you would decide whether the electronics company should accept or reject the order of display screens using the data gathered by the trained engineer.

Selected responses to the Display Screens task

1. Student 719
   - *Inference?* "Yes, statistical inference should be used... we can find the margin of error and a confidence percentage that will lead us to accept or reject the bulk order."
   - *Method?* "If 5% of the display screens from the supplier are bad, then that means 92.5 or more of them have to be good in order to accept them."
2. Student 122
   - *Inference?* "Statistical inference should be used because the sample is random every time."
   - *Method?* "You would have the trained engineer check each screen and if 8 or more of the screens were bad, send the order back."

Observation: Discerning between deterministic and stochastic inquiry

- The pattern of self-contradiction is particularly of interest here.
- 32 of the 178 students ($\approx$ 18%) incorrectly claim statistical inference **IS** valid for the Display Screens task, BUT then described a **deterministic** solution.
- The converse was regularly observed in the note identification task. Several students incorrectly claimed statistical inference was **NOT** valid, and then propose an **inferential** solution.

Additional examples (deterministic/stochastic inquiry)

In the Note Identification task, a stochastic inquiry, we see the converse issue

1. Student 1541
   - *Inference?* "No statistical inference should not be used..."
   - *Method?* "You can use hypothesis testing to conclude a result. (1.) Determine the null and alternative hypothesis (2.) Find the p-value (3.) Decide if the result is statistically significant (4.) Make a conclusion"
2. Student 1293
   - *Inference?* "Statistical inference should not be used to determine if Carla has a good ear for music or not because the sample size is too small and may not give any usable data."
   - *Method?* "The best way to decide if Carla has an ear for music would be to run a significance test with a confidence interval of 95%."

Conclusions

1. Population as a process:
   - finding: some students uncomfortable with a process as population
   - finding: some students unnecessarily imposed a more tangible population
   - illustrates a key challenge while "shuttling" from context to archetype described by Wild & Pfannkuch (1999)
2. Lexical ambiguity/misconceptions of parameter
   - finding: large variability of concepts ascribed to parameter

    - B. & delMas (in review) launched an extensive follow-up study of this issue and corroborated concurrent work of Kaplan & Rogness (2018).
    - evidence of difficulty "shuttling" from archetype to context described by Wild & Pfannkuch (1999)
3. Deterministic vs stochastic inquiry (i.e. Is this a statistical question?)
    - finding: students self-contradict... they advocate for one approach and then describe the opposite
    - evidence of difficulty discerning between deterministic and stochastic inquiry described by Franklin & Garfield (2006)

What do you learn when you ask questions like this?

- We test our students' reflexes (Chance, 2002)
- Opportunities to distinguish between deterministic and stochastic inquiry
- Isolate each direction of "shuttling" as statistical thinking takes place
- Better insight into understanding & misconceptions of our students

References

1. Beckman, M. D. (2015). *Assessment of cognitive transfer outcomes for students of introductory statistics* (Doctoral dissertation, University of Minnesota—Twin Cities). Retrieved from http://iase-web.org/documents/dissertations/15.MatthewBeckman.Dissertation.pdf
2. Beckman, M. D., delMas, R. C. (in review). Statistics students' identification of inferential model elements within contexts of their own invention.
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7. Kaplan, J.J. & Rogness, N. (2018). Increasing statistical literacy by exploiting lexical ambiguity of technical terms. *Numeracy, 18*(1).
8. Rossman, A. J., & Chance, B. L. (2001). Workshop statistics: Discovery with data (2nd ed.). Emeryville, CA: Key College Publishing.
9. Singley, M. K., & Anderson, J. (1989). *The transfer of cognitive skill.* Cambridge, MA: Harvard.
10. Wild, C.J. & Pfannkuch, M. (1999). Statistical Thinking in Empirical Enquiry. *International Statistical Review, 67*(3), 223-265.

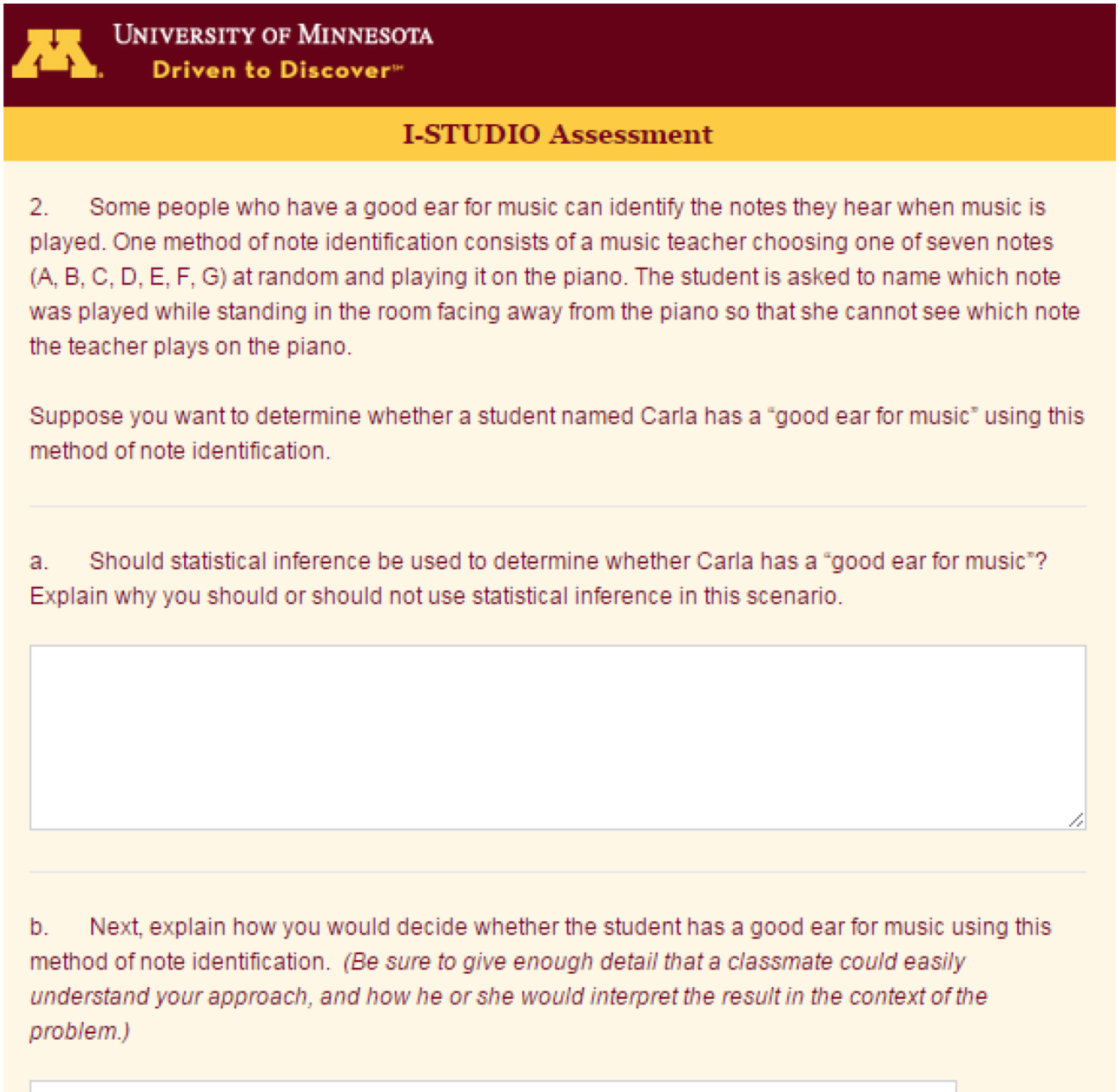
Backup Slides

Note Identification Task

Display Screen Quality

Rossman Chance Task

Reliability and Validity Summary



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I-STUDIO Assessment

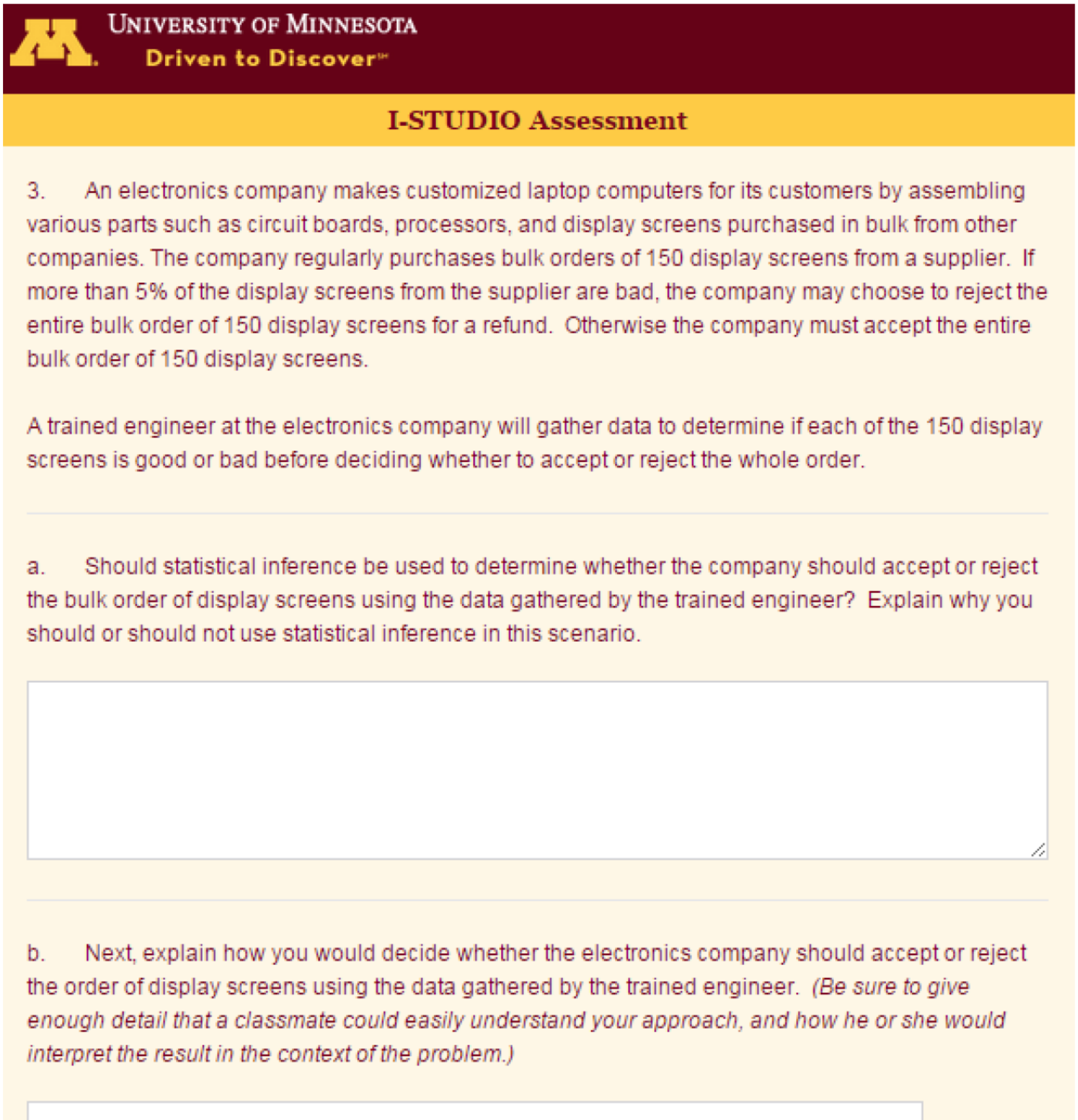
2. Some people who have a good ear for music can identify the notes they hear when music is played. One method of note identification consists of a music teacher choosing one of seven notes (A, B, C, D, E, F, G) at random and playing it on the piano. The student is asked to name which note was played while standing in the room facing away from the piano so that she cannot see which note the teacher plays on the piano.

Suppose you want to determine whether a student named Carla has a "good ear for music" using this method of note identification.

a. Should statistical inference be used to determine whether Carla has a "good ear for music"? Explain why you should or should not use statistical inference in this scenario.

b. Next, explain how you would decide whether the student has a good ear for music using this method of note identification. *(Be sure to give enough detail that a classmate could easily understand your approach, and how he or she would interpret the result in the context of the problem.)*

Figure 1:



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I-STUDIO Assessment

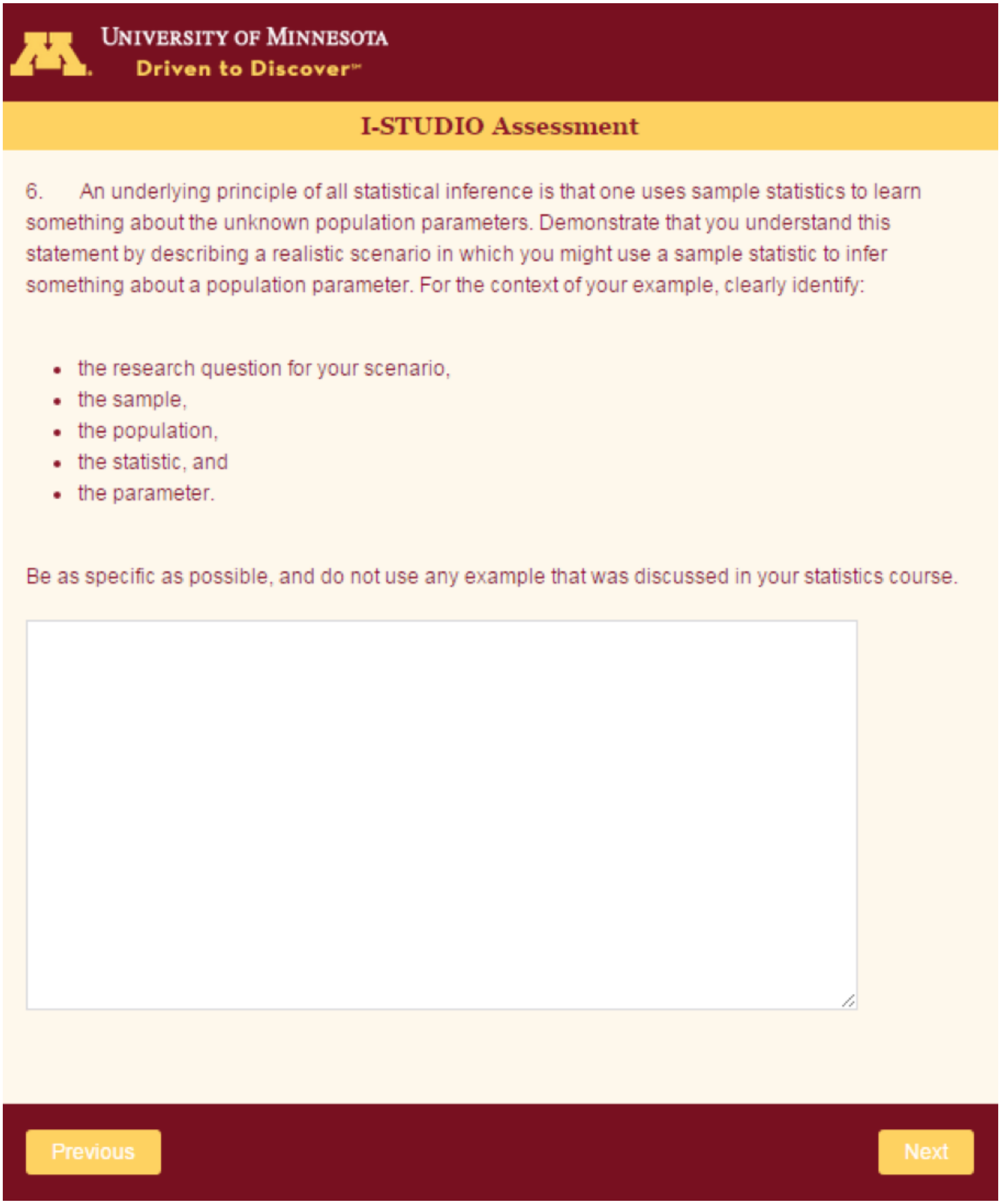
3. An electronics company makes customized laptop computers for its customers by assembling various parts such as circuit boards, processors, and display screens purchased in bulk from other companies. The company regularly purchases bulk orders of 150 display screens from a supplier. If more than 5% of the display screens from the supplier are bad, the company may choose to reject the entire bulk order of 150 display screens for a refund. Otherwise the company must accept the entire bulk order of 150 display screens.

A trained engineer at the electronics company will gather data to determine if each of the 150 display screens is good or bad before deciding whether to accept or reject the whole order.

a. Should statistical inference be used to determine whether the company should accept or reject the bulk order of display screens using the data gathered by the trained engineer? Explain why you should or should not use statistical inference in this scenario.

b. Next, explain how you would decide whether the electronics company should accept or reject the order of display screens using the data gathered by the trained engineer. *(Be sure to give enough detail that a classmate could easily understand your approach, and how he or she would interpret the result in the context of the problem.)*

Figure 2: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I-STUDIO Assessment
6. An underlying principle of all statistical inference is that one uses sample statistics to learn something about the unknown population parameters. Demonstrate that you understand this statement by describing a realistic scenario in which you might use a sample statistic to infer something about a population parameter. For the context of your example, clearly identify:
• the research question for your scenario,
• the sample,
• the population,
• the statistic, and
• the parameter.
Be as specific as possible, and do not use any example that was discussed in your statistics course.
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Figure 3: