Teaching Critical Thinking (in Statistics) for Natural Resource Education

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Context

- Diverse research-focused department, ~60 graduate students

  - Silviculture, ecology, wildlife, landscape ecology, nutrient and carbon cycling, genetics

- Graduate course

- Students bring their own research to course

What is it with Statistics anyway?

- Role of statistics and critical thinking in life and research
- Teaching statistics and cognitive theory
- Learning outcomes for the course
- Course Structure
- Role of the course in the broader curriculum

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Role of statistics in life and research

- Increasing role of information and science and the need to be able to evaluate strength of information in data

  - "4 out of 5 dentists surveyed recommend sugarless gum for their patients who chew gum"

GAZETTE TIMES · 1/10/90

Siuslaw plan had math flaw

Change raises timber harvest

By Steve Jones
Gazette-Times reporter

■ State urges changes/A2

A major math error subtracted 40 million board feet of timber from the annual sales level proposed in the draft Siuslaw National Forest plan, Gov. Neil Goldschmidt's timber planners announced Tuesday.

Correcting the error and other management changes should allow the Corvallis-based forest to increase annual sales in the decade from 295 million board feet proposed in a draft plan a year ago to 340 million board feet, said Gail Achterman, Goldschmidt's aide for natural resources.

During the 10 years from 1979 to 1988, the forest has sold an average of 338 million board feet a year.

The error involved converting timber volumes from cubic feet to board feet and has been embedded in the forest's data for more than a decade, said Norm Johnson, an Oregon State University professor and Goldschmidt's timber analyst. The flaw was contained "in some obscure stuff that took us a while to unravel," he said.

Tony Vander Heide, planning staff officer for the Siuslaw, said Johnson pointed out the problem early last year. It was late summer before it was found in forest inventory data compiled in 1974.

"We had to go back to some basic (forest) plot inventories to find the problem," said Vander Heide.

He said the erroneous data was plugged into a forest computer model known as ForPlan that all national forests use to create their forest plans. Once in the model, the flaw skewed sales projections forestwide.

That isn't to say, however, that the forest has been miscalculating all its sales figures, said Vander Heide. Only long-range plans were affected by the error.

Those plans, however, drive key decisions. The resource plan

See 'Forest'/back page

  - "(Reuters) - A study in Taiwan has found that smokers are twice as likely to develop active tuberculosis compared to people who have never smoked…"

What's missing in Statistical Education?

"There is a growing feeling in the statistical community that significant changes must be made in statistical education.

Statistical education has traditionally focused on developing knowledge and skills and assumed that students would create value for the subject in the process.

This approach hasn't worked."

Snee 1993

Applying Cognitive Theory

1. Students learn best when they practice and perform on their own.
2. Knowledge tends to be specific to the context in which it is learned.
3. Learning is more efficient with students receive real-time feedback on errors
4. Learning involves integrating new knowledge with existing knowledge
5. Learning becomes less efficient as the mental load increases

Lovett and Greenhouse 2000

What is statistical literacy?

Understanding statistics well enough to be able to consume the information, think critically about it and make good decisions based on that information.

1. The ability to identify questions
2. Collect evidence (data)
3. Discover and apply tools to interpret the data
4. Communicate and exchange results
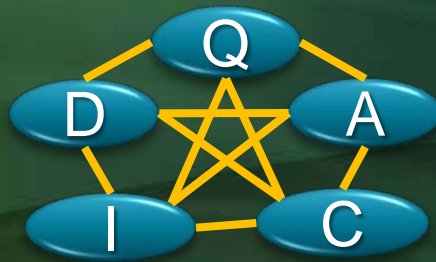
Critical Thinking

Rumsey, 2002

What is statistical literacy?

A consumer of information should be able to:

- The type of study used
- The sample that was selected
- The measurements that were made
- The graphs that were generated from the data

- The <u>statistics</u> that were generated from the data
- <u>Probability statements</u> made based on the data

- Claims that were made based on the data
- The amount of information that was provided to the consumer
- Limitations of the study   Gal 2002

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Components of Research
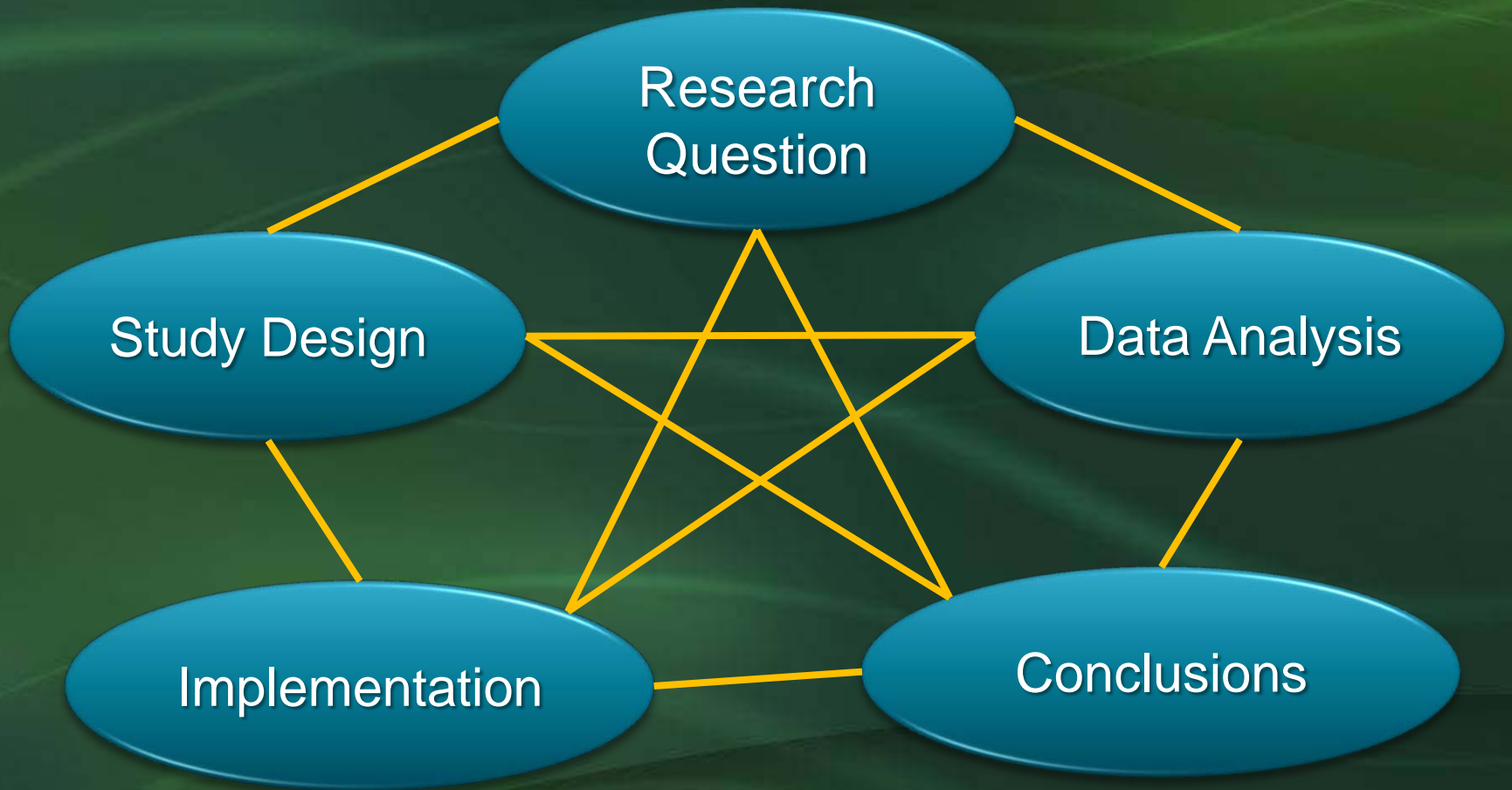
FS 523   Natural Resources Data Analysis

Course Structure

- 2 80-minute classroom periods
- 1 60 minute discussion period
- 1 120 minute computer lab period
- One-on-one consulting with statistician outside of class
- Weekly computer assignments
- "Final" project
- Weekly discussion sections
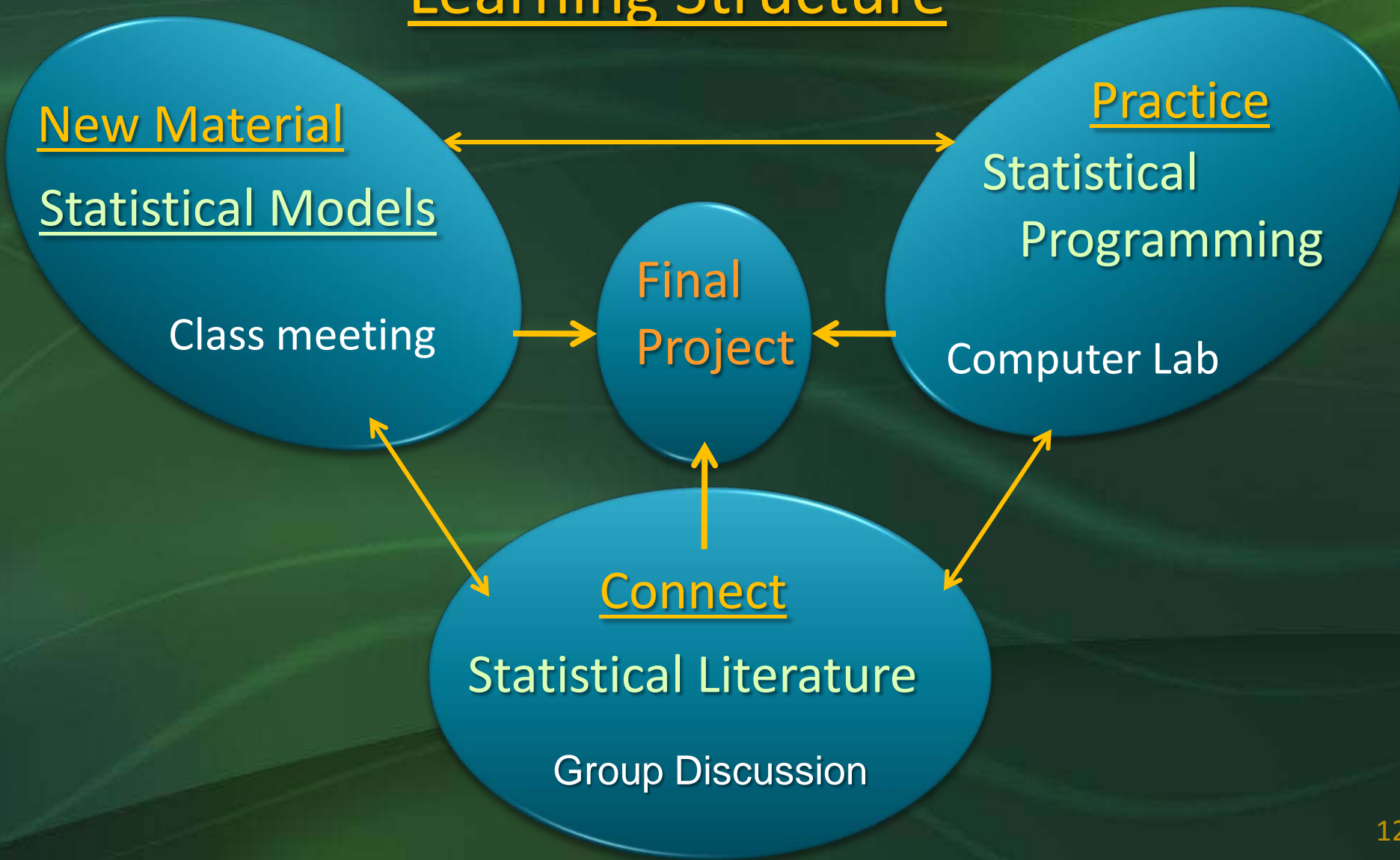
http://www.cof.orst.edu/cof/teach/fs523/

Natural Resources Data Analysis

Learning Objectives

- Critically evaluate their *literature* with respect to study design, data analysis strategies and the subsequent data analysis.

- Design and conduct their own data *analysis* strategy

- Demonstrate effective verbal and written *communication* of statistical concepts and scientific data analysis.
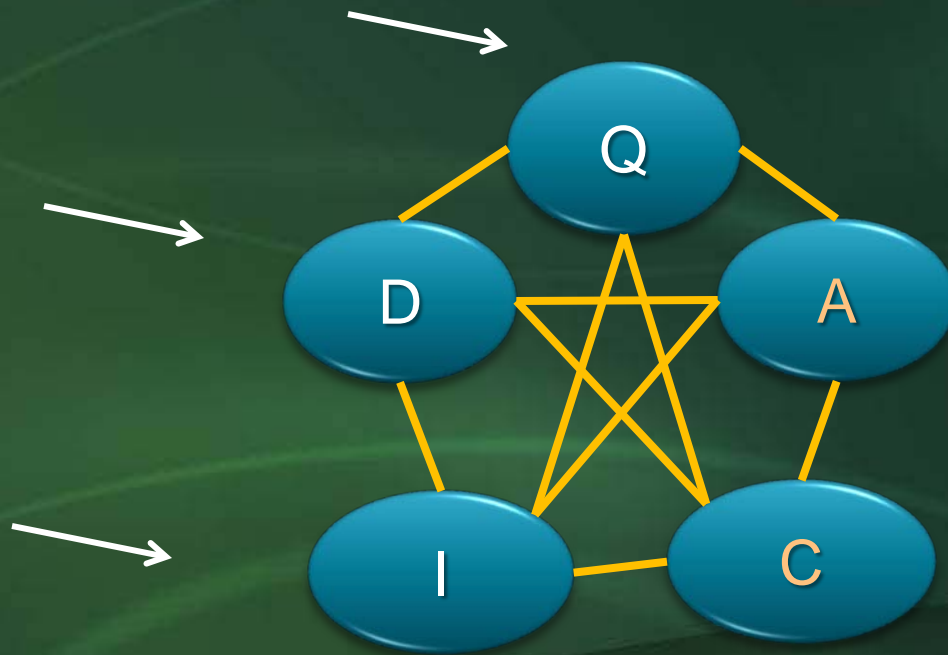
Teaching How to Learn

Natural Resources Data Analysis

Learning Structure

New Material

Statistical Models

Class meeting

Practice

Statistical Programming

Computer Lab

Final Project

Connect

Statistical Literature

Group Discussion

Practice: Weekly Lab Assignments

Instructor provides Research Question, Design, Implementation

Student provides data analysis strategy and programming

based on strategy, written conclusions in context

Practice - Weekly Lab Assignments

A researcher believed that different thinning regimes would have different effects on diameter growth of 25 year old Douglas-fir. From a list put out by the Forest Service of several hundred 25 year old stands of Douglas-fir in Western Oregon, she randomly selected 21 on good site quality ……….. She randomly assigned 7 stands to each of three stand densities: 100, 225 and 325 tpa. Immediately after the stands were thinned, she randomly selected 15 of the remaining trees in each stand. On these she measured…… Five years later, she returned to each stand and remeasured the 15 trees.

Practice - Weekly Lab Assignments

Value Added:

1. A very parallel but different example is worked in class

   Students are required to link their assignment to the worked example by
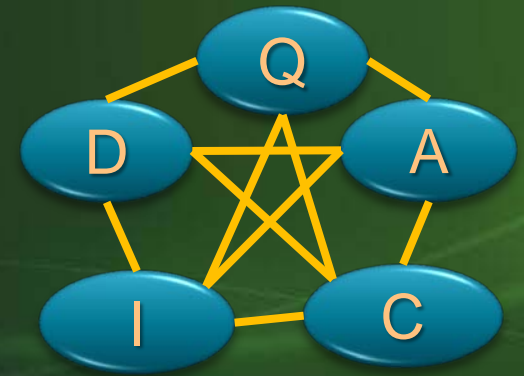   (a) Changing computer coded
   (b) Writing an independent conclusions section
   (c) Answer key is provided for the example ONLY

2. Assignments are chosen to address analyses needed by student group.

Course Structure
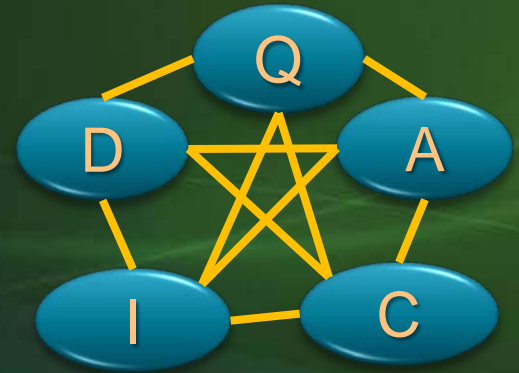
Connect - Weekly Discussion

- Student led – NOT instructor led
- Peer reviewed literature in natural resources
  - Scientific thinking, eg Platt, Hurlbert
  - Special topics in statistics: current/controversial issues, pros/cons of methods
  - Poor examples
  - Critique of professional writing

Course Structure

Final Project Assignment

- Provide written description of Research Question, Design, Implementation
- Peer-review classmate's written description
- Develop a data analysis strategy and programming for student identified dataset
- Carry out analysis – get instructor feedback
- Draw conclusions in context of the research question.

Putting the Pieces together

- New subject material demonstrated in class meetings

- Critical thinking skills for study description and interpretation of data

- Programming is practiced in lab in the example and the assignment

- In discussion illustrates how the concepts are discussed in the application literature and students practice communication

- In the final project the ideas are applied in a context that is valued by the student.
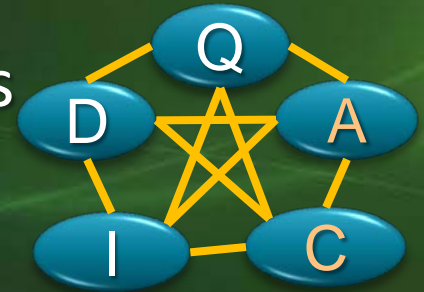
Challenges

- Initial *communication and reasoning skills of graduate students* vary widely
- Student wish-list is TOO long!
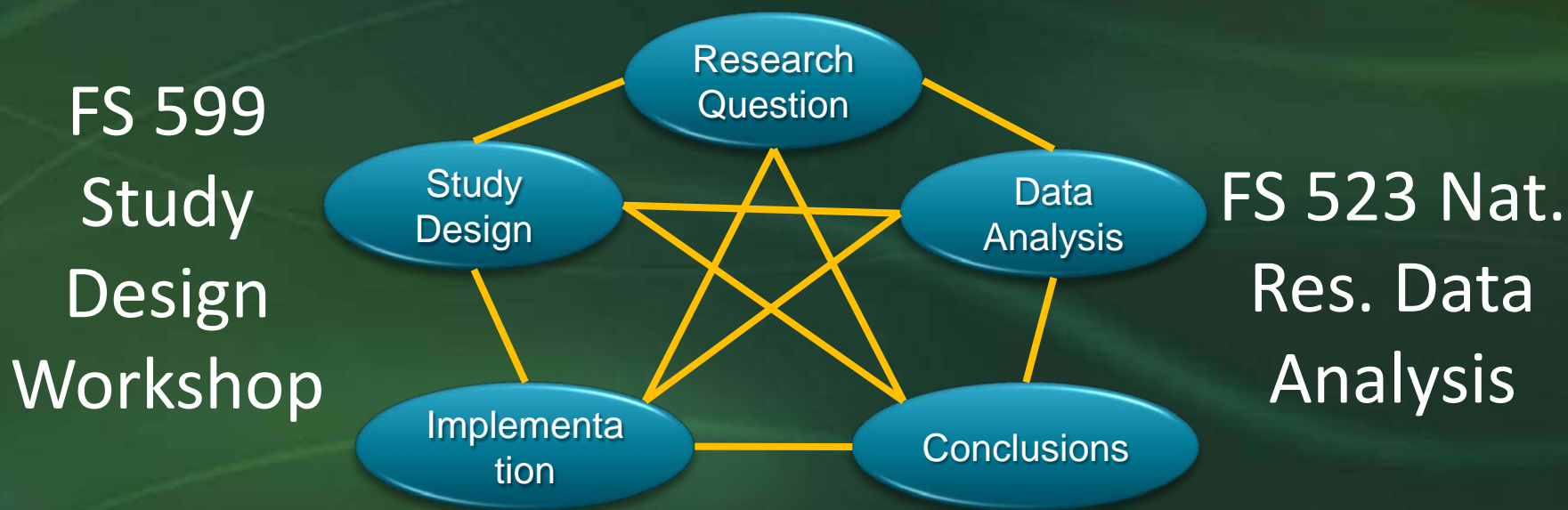- Exceptionally time intensive

Successes

- Draws students from other disciplines

  - Fisheries and Wildlife, Food Science, Range, Botany, Horticulture, Crop and Soil Science, Zoology

- Students perceive gains in their learning

- Well prepared for future interactions

- Consistently identified as most useful <u>learning</u>

Role in the broader Forest Science curriculum

FS 520 Posing Researchable Questions

FS 599 Study Design Workshop

FS 523 Nat. Res. Data Analysis

Research Question

Study Design

Data Analysis

Implementation

Conclusions

Teaching How to Learn

Course Future:

- Course Development never ends

  - Ask the students

  - One day at a time

- ……on to online….

Thank you !

Questions?

http://www.cof.orst.edu/cof/teach/fs523/