

Learning Efficiency in Research-Based Courses vs. Traditional Teaching Courses

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Introduction

In recent years, it has been discovered that traditional curricula for entry-level laboratory courses misrepresent the true experiences of working in the scientific field. It often leaves students with misconceptions as to what this work entails and results in a lack of preparation for further research experiences. Our investigations on this matter include several studies which delve into the goals of the different types of course design and measure the effectiveness of the different designs in achieving the desired goals. These studies show support for inquiry- and research-based courses and related teaching methods. Inquiry-based laboratory courses, in comparison to traditional “cookbook” laboratory teaching methods, better prepare students for careers in science-related fields, improves scientific writing abilities, fosters continued interest in research and related work, and encourages higher-level understanding of methodology and significance of results.

“The power of an inquiry-based approach to teaching and learning is its potential to increase intellectual engagement and foster deep understanding through the development of a hands-on, minds-on and ‘research-based disposition’ towards teaching and learning” - Neil Stephenson

Teaching Methodologies

What Makes an Inquiry Based Laboratory Course Different from a Traditional Laboratory Course?

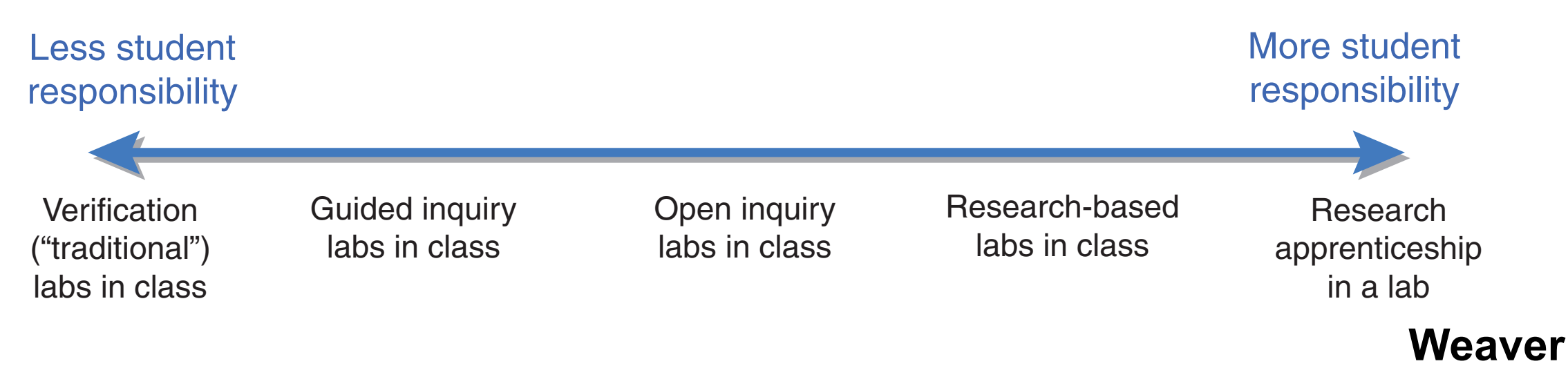
Inquiry based courses focus more on encouraging students to be proactive in developing their own personal understanding of material being presented, rather than memorizing, following strict guidelines/instructions, observing techniques, etc.

TABLE 1

Comparison of goals for two undergraduate biology laboratory courses.

Goals for research-based lab (experimental)	Goals for traditional “cookbook” lab (comparison)
<ol style="list-style-type: none"> Students will be able to conduct guided inquiry on open-ended questions that reflects biological research practice in the context of ecology. Students will be able to analyze open-ended, guided inquiry data and propose justifiable conclusions. Students will conduct elements of scientific research both independently and collaboratively. Labs will stimulate student interest in future biological research and encourage participation in research endeavors. Students will develop critical-thinking skills in biological research that are transferable to other research experiences. Students will experience the successes and failures of lab research. Students will experience the successes and challenges of collaborative research. Students will communicate results in a discipline-appropriate manner through various media. 	<ol style="list-style-type: none"> To present an overview of the theory and practice of experimental biology using several representative fields of biology as model systems. To teach the methodology by which a well-conducted experiment is planned, appropriately observed, and critically analyzed. To provide a general framework for scientific writing and to train you for proficiency in written scientific presentation. To stimulate interest in biological research; to familiarize you with scientific resources in the library; and to encourage future participation in research endeavors.

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Significance

- Determine whether research-based or traditional lab structure better achieves curriculum standards set for a specific course.
- Compare student performance, in the context of information comprehension/retention, between students in inquiry-based laboratory courses to those in traditional “cookbook” labs
- Identify either inquiry-based or cookbook labs as a more effective means of educating student

Findings

Table 4. Student feedback about laboratory and classroom

	(+)Lab	(-)Lab	(+)Class	(-)Class
Traditional labs (S'2000, n = 91)	1	1	46	1
TS Inquiry labs (S'2001, n = 90)	35	7	68	2
Traditional labs (F'2001, n = 63)	0	3	6	12
TS Inquiry labs (F'2002, n = 81)	1	0	11	4
TS Inquiry labs (S'2003, n = 99)	22	9	25	6
Totals: Traditional labs	1 (20%)	4 (80%)	52 (80%)	13 (20%)
Totals: TS Inquiry labs	58 (78%)	16 (22%)	104 (90%)	12 (10%)

Luckie

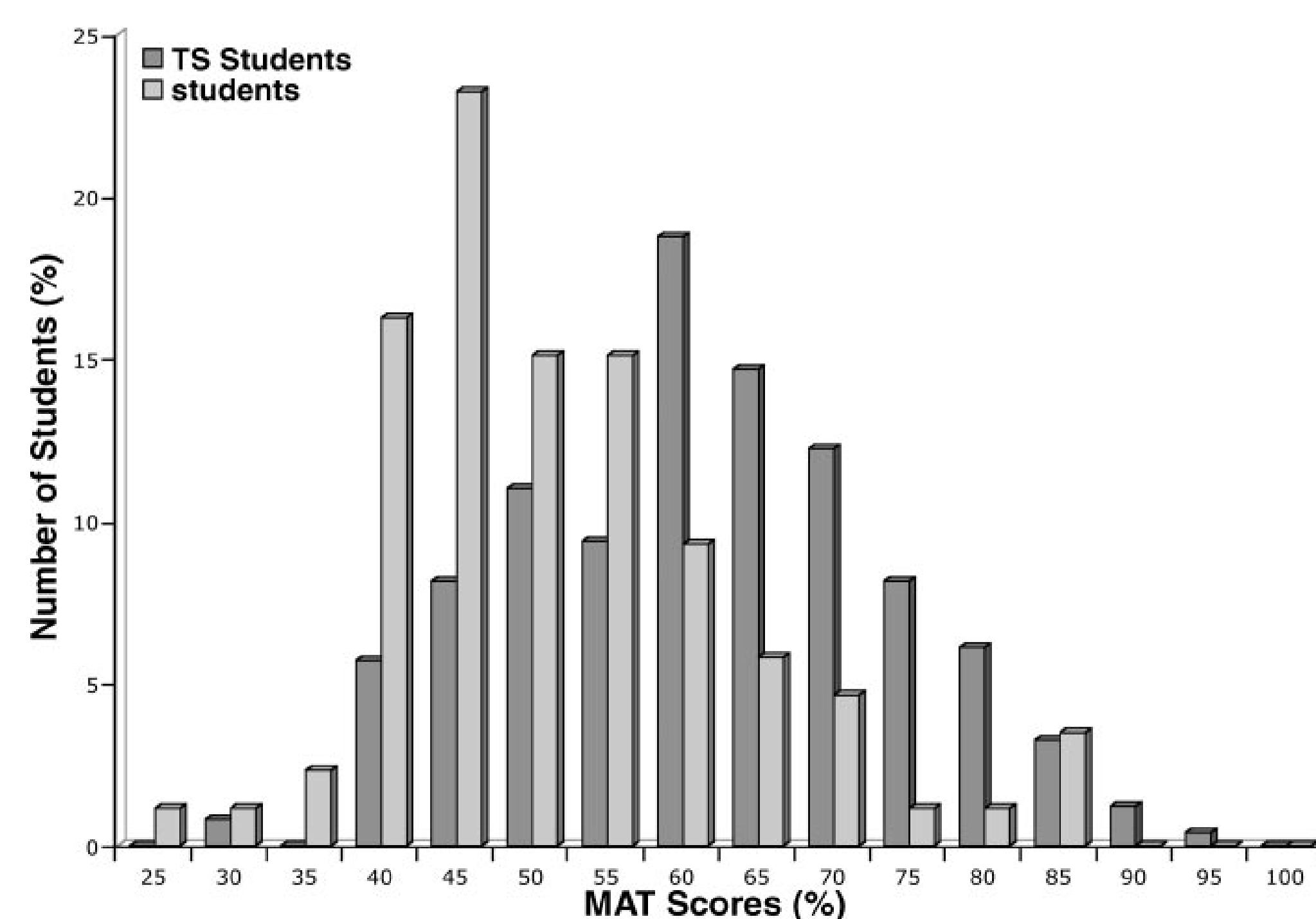
This figure is a quantification of student satisfaction in inquiry-based versus that of students taking traditional lab courses. Surveys were sent to students, to which they responded with their open-ended feedback regarding the course. These responses were then identified as either being overall positive or negative, and the percentages of positive responses were compared to those of negative responses.

TABLE 3

Pre/postcourse survey means, standard deviations (in parentheses), gain scores, and effect sizes (postcourse results) for the question: “What is your level of agreement with the following statements related to biology lab courses?”

	Comparison (n = 20)			Experimental (n = 20)			Effect size
	Pre	Post	Gain	Pre	Post	Gain	
1. I prefer lab courses that explore a set of research questions focused on a single continuous topic.	2.5 (0.61)	1.9 (0.61)	-0.60**	3.4* (0.81)	3.6* (0.61)	0.20 (0.95)	2.8
2. I prefer lab courses that explore an open-ended question for which the answer is not predetermined.	2.6 (0.61)	2.6 (0.95)	0.0	3.2* (0.83)	3.7* (0.49)	0.50** (0.89)	1.5

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Luckie

A 40-question, multiple choice exam with questions that test knowledge relevant to material covered in an introductory laboratory course was administered to “TS” (an inquiry-based program studied by Luckie) students and those in an equivalent, traditional lab course. Since unequal numbers of students were tested from the inquiry-based group (n = 245) and traditional group (n = 86), percentages of the students that earned each score were compared. Those students in the inquiry-based course (average = 60%) outscored those in the traditional course (average = 50%).

Conclusion

- Students prefer being in a learning environment in which there are no predetermined results
- There is significant difference in the preference for an inquiry-based lab in comparison to a traditional lab
- Student grades and standardized test scores better benefit from experience in inquiry-based courses than traditional lab courses.

“Tell me and I forget, teach me and I may remember, involve me and I learn.” – Benjamin Franklin

References

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