Taking a RISC: Results from the RISC Survey

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Introduction

In my report of my work in assessing the benefits to students who participated in undergraduate research (Lopatto, 2010) I devoted a chapter to the topic of disciplines and interdisciplinary work. I acknowledged a report from the National Academy of Sciences called *Facilitating Interdisciplinary Research* and related a variety of observations by educators on the topic of interdisciplinarity. At the time I was working with colleagues at several colleges[1] to modify the Classroom Undergraduate Research Experience (CURE) survey to capture the additional benefits of engaging in research-like experiences that had an interdisciplinary dimension. The resulting instrument is the Research on Integrative Science Curriculum (RISC) survey. The RISC survey illustrates an inductive approach to describing interdisciplinary teaching and learning. My attempts to learn the definition of the term interdisciplinary were frustrating. I attended professional meetings at which a learned expert in interdisciplinary learning would hold forth, inviting audience members to describe their efforts toward an interdisciplinary undergraduate research program or curriculum. Without exception, the proffered examples were rejected by the expert as exemplars of interdisciplinarity. The subsequent discussions bogged down in attempts to delineate the interdisciplinary from the multidisciplinary, the transdisciplinary, or even the metadisciplinary. My attendance at working groups or committees who had expressed enthusiasm about interdisciplinary research and learning were no more satisfying. Such groups demurred from defining the term, and perhaps more surprising, seldom asked what the benefits of interdisciplinary learning are from the students' point of view. Even assuming that some areas of the curriculum were supposed to be self-evidently interdisciplinary (e.g., environmental science, neuroscience) did not reflect the student's true experience. Once, when we asked a student researcher if she considered her work interdisciplinary, she replied, "No, it's neuroscience."

The RISC survey assumes no a priori definition of interdisciplinary. The RISC survey proceeds on the assumption that interdisciplinarity emerges from the connection between what the course instructor intends and what the students learn. As a research instrument, the RISC has three components. One is for the course instructor. Here, the instructor announces their intent by evaluating a "level of emphasis" for various course elements. Many of the 48 elements are similar to those used in the CURE survey. In addition, a new set of items was added based on a reading of literature, discussions with colleagues, and attendance at frustrating meetings. Some, such as "students work on a problem that requires integrating ideas from two or more sciences" or "students work on a problem that requires integrating ideas from both science and non-science

[1] The original contributors included faculty from Carleton College, Grinnell College, Hope College, St. Olaf College, and Whitman College.

disciplines" were proposed as essential to interdisciplinary work; some, such as "students work on defining a problem and refining the definition while solving the problem" attempted to capture the process of working through the research problem. Some items, such as "students read a textbook" were a kind of control question. Finally, the key item for the instructor was "students study an interdisciplinary problem." For this item, instructors were asked to designate whether there was minor emphasis, moderate emphasis, or major emphasis on interdisciplinary problems.

If a course instructor designates having a minor emphasis, moderate emphasis or major emphasis on an interdisciplinary problem[2], we have the makings of a comparative study. If we provide students in the courses the opportunity to evaluate the same set of items that we presented to the instructor, we should see the instructor's profile of emphasized items resonate with the student evaluations. For those instructors who devote a major emphasis to an interdisciplinary problem, we may see a distinctive pattern of activities and outcomes that help characterize the interdisciplinary experience.

The description that follows is based on reports from 2219 students at 41 college and universities from the years 2010 to 2019. The data are restricted to respondents who completed both the pre- and post-course surveys. Most of the courses evaluated indicated integration between two science disciplines.

Survey results

Background statistics

Gender categories: Female – 1438 (66%), Male – 738 (34%)

It is not atypical for student surveys to be answered by more self-identified women than men. Students uncomfortable with the gender binary had the option of not responding.

Ethnic categories (Table 1)

	Frequency	Percent
Alaskan Native	1	0.0%
American Indian	8	0.4%
Asian American	133	6.2%
Black or African American	106	5.0%
Filipino	7	0.3%
Foreign National	75	3.5%
Hawaiian	2	0.1%
Hispanic/Latino	116	5.4%
Pacific Islander	7	0.3%
White	1546	72.3%
Two or more races	85	4.0%

[2] The RISC survey instructor form also had a category that was designated "no emphasis or N.A. [not applicable]". The few responses in this category proved to be uninterpretable, and so are not part of this analysis.

Other	53	2.5%

Current status/rank (Table 2)

	Frequency	Percent
High School	7	0.3%
First-year college student	677	30.7%
Second-year college student	569	25.8%
Third-year college student	446	20.2%
Fourth-year college student	468	21.2%
Graduate or medical student	7	0.3%
Other	29	1.3%

It is noteworthy that almost a third of the respondents were first-year college students. In discussions of interdisciplinary learning there is a viewpoint that students must master one discipline before they can accommodate interdisciplinary work. There is a rival view that the world itself is not divided into disciplines and so it is better to encounter interdisciplinary problems early in one's college career.

Table 3.

Indication of Post-graduate plans (post course survey)	Frequency	Percent
I have not considered post-graduate education	273	15.9%
I now plan NOT to pursue post-graduate education	37	2.1%
I now plan to pursue a Master's degree in science-related field	373	21.7%
I now plan to pursue a Doctoral degree in science-related field	370	21.5%
I now plan to pursue a Master's degree in a field other than science	168	9.8%
I now plan to pursue a Doctoral degree in a field other than science	49	2.8%
I now plan to pursue a medical degree	376	21.8%
I now plan to pursue a law, architectural, or other degree	75	4.4%

Keep in mind that most of the respondents were in science courses and that approximately 70% had declared their major. The most frequently represented disciplines were the biological sciences, chemistry, math/statistics, and psychology. The range of majors, double majors, minors, and concentrations was broad and included the leading social sciences (anthropology, sociology) as well as some humanities and fine arts. Among students who had not yet declared a major, about two-thirds indicated they would definitely or most likely major in a science.

Course Elements

The course elements section is the longest section of the RISC survey. In the pre-course survey, students are asked to "give an estimate of your current level of ability before the course begins." In the post-course survey, students are asked to "rate how much learning from each element you experienced from this course." The scale for both pre- and post-course surveys is 1 to 5, with 1 indicating little or no gain and 5 indicating very large gain. The term "gain" was used as a proxy for the self-evaluation of learning.

Some of the items in the list were taken from the CURE survey and represent a sampling of typical processes and gains in courses that may be either "traditional" or "research-like." An additional 25 items were generated from literature on interdisciplinary learning or conversations with colleagues on the RISC project. In what follows, I take license with two aspects of the survey. First, I separate the CURE items from the new interdisciplinary items. Second, I compare the pre-survey means to the post-survey means.

Course elements taken from the CURE survey are shown in the next table (Table 4). The table lists the course element, the pre-course mean, standard deviation (SD), and median, followed by the post-course mean, standard deviation, and median. On the right is a column modeled after a statistic called "Cohen's d". The difference is the post-survey mean minus the pre-survey mean, standardized by dividing the difference by the standard deviation of the pre-course data. The results should be interpreted with caution. The comparisons that either showed no change or a negative change seem dominated by items relating to traditional courses (tests in class, read a textbook, listen to lectures). The biggest positive differences occur for items that assign more responsibility to the student (a project of student design, a student research proposal).

These results resemble the results of the CURE survey when we compare traditional lecture/lab science courses to courses that include a research element, however, they do not reveal information about interdisciplinary courses

Table 4. These course elements are similar to those used in the CURE survey.	Precourse			Postcourse			Difference
	Mean	SD	Median	Mean	SD	Median	(in SD units)
A scripted lab or project in which students know the expected outcome.	3.53	0.95	4	3.25	1.08	3	-0.29
A lab or project in which only the instructor knows the outcome.	3.44	0.89	3	3.43	1.00	3	-0.01
At least one project that is assigned and structured by instructor.	3.88	0.82	4	3.67	0.98	4	-0.26
A project in which students have some input into the research process and/or what is being	3.13	1.00	3	3.77	1.07	4	0.64
A project entirely of student design.	2.74	1.10	3	3.57	1.20	4	0.75
Work individually.	3.95	0.90	4	3.35	1.10	3	-0.67
Work as a whole class.	3.39	0.93	3	3.46	1.20	4	0.08
Work in small groups.	4.00	0.74	4	3.84	1.00	4	-0.22
Become responsible for a part of the project.	3.88	0.80	4	3.68	1.10	4	-0.25
Read primary scientific literature.	3.30	1.00	3	3.51	1.10	4	0.21
Write a research proposal.	2.42	1.10	2	3.06	1.30	3	0.58
Collect data.	3.72	0.89	4	3.63	1.15	4	-0.10
Analyze data.	3.64	0.87	4	3.83	1.00	4	0.22
Present results orally.	3.27	0.90	3	3.32	1.20	3	0.06
Present results in written papers or reports.	3.60	0.87	4	3.53	1.10	4	-0.08
Present posters.	2.94	0.99	3	3.01	1.34	3	0.07
Critique work of other students.	3.16	0.89	3	3.07	1.16	3	-0.10
Listen to lectures.	4.20	0.75	4	3.50	1.10	4	-0.93
Read a textbook.	4.22	0.73	4	2.92	1.30	3	-1.78
Work on problem sets.	3.79	0.95	4	3.29	1.23	3	-0.53
Take tests in class.	4.32	0.65	4	3.12	1.20	3	-1.85
Discuss reading materials in class.	3.90	0.81	4	3.36	1.20	3	-0.67
Maintain lab notebook.	3.36	1.10	4	3.06	1.30	3	-0.27

The table below (Table 5) shows the 25 items that were generated to capture the goals and process of interdisciplinary courses. The means, medians, and standard deviations (SD) are shown. The last column is calculated by taking the difference between pre- and post-means (post minus pre) and dividing by the SD of the pre-survey data. The table captures many positive changes in the items from pre- to postcourse. Only three differences have negative values (referring to disciplinary knowledge, receiving coursework from more than one discipline, working with students from other disciplines). Standouts among the positive differences are computer modeling of complex systems, studying problems with multiple causes, and learning about two disciplines so that new insights emerge. The list of items appears to capture the experience of an interdisciplinary course. Note that the items are not an affirmation of content knowledge or disciplinary methodology. Instead, they encompass the behavioral activities that may be typical of a course the instructor intends to be interdisciplinary.

We have information from course instructors concerning the level of emphasis they placed on these same activities. One straightforward item evaluated by the instructors is "studying an interdisciplinary problem." When we match students with their course instructors, we find that we have survey data for three groups, "minor emphasis", "moderate emphasis", and "major emphasis" on interdisciplinary problems. Suppose we group the student data into these three categories. We then examine what pattern of results might emerge. We might expect that the more emphasis an instructor placed on interdisciplinary problems, the higher students would rate the activities related to the course.

Table 5. These items were used to understand interdisciplinary course aims and activities	Precourse			Postcourse			Difference
	Mean	SD	Median	Mean	SD	Median	(in SD units)
Working on problems that have no clear solution.	3.01	0.95	3	3.34	2.20	3	0.35
Connecting your personal experience to the course problem or problems.	3.33	0.96	3	3.53	1.14	4	0.21
Learning that the use of disciplinary knowledge needs to be accurate and fair.	3.73	0.86	4	3.6	1.00	4	-0.15
Receiving assigned coursework from more than one discipline or area of study.	3.76	0.93	4	3.5	1.12	4	-0.28
Learning that disciplines may approach problems in different and sometimes conflicting ways.	3.56	0.89	4	3.74	1.10	4	0.20
Using instruments or materials borrowed from another discipline or field of study.	2.93	0.89	3	3.25	1.15	3	0.36
Working with students who major (or probably intend to major) in other disciplines or fields of study.	3.52	0.94	4	3.5	1.13	4	-0.02
Learning to find similarities and differences between disciplines or fields of study.	3.39	0.88	3	3.5	1.00	4	0.13
Working on defining a problem and refining the definition while solving the problem.	3.24	0.92	3	3.41	1.10	3	0.18
Working on a problem that requires integrating ideas from two or more sciences.	3.04	1.01	3	3.51	1.15	4	0.47
Studying an interdisciplinary problem.	3.06	0.98	3	3.54	1.12	4	0.49
Spending the entire course on one or a few problems.	2.55	1.10	2	3.05	1.30	3	0.45
Working on a problem that requires integrating ideas from both science and non-science disciplines.	2.97	0.93	3	3.35	1.20	3	0.41
Attempting a complete understanding of a complex problem.	3.30	0.83	3	3.64	1.00	4	0.41
Learning to ask "big questions" that implicate more than one discipline in a solution.	3.21	0.91	3	3.63	1.10	4	0.46
Talking with faculty members from other disciplines or fields of study.	3.15	0.97	3	3.34	1.25	3	0.20
Reading primary literature from multiple disciplines or fields of study.	3.10	0.94	3	3.25	1.20	3	0.16
Learning to translate the specialized language of a discipline into the language of other disciplines.	2.67	1.02	3	3.25	1.20	3	0.57
Learning about two (or more) disciplines so that new insights emerge from considering them together.	2.77	0.98	3	3.38	1.12	3	0.62
Judging the relative contribution of disciplines to the solution of the problem.	2.68	0.96	3	3.21	1.10	3	0.55
Creating new metaphors, analogies, or models to understand problems.	2.85	1.00	3	3.28	1.20	3	0.43
Learning computer modeling of complex systems.	2.15	1.00	2	3.15	1.30	3	1.00
Studying problems with multiple causes that operate simultaneously and interactively.	2.68	0.97	3	3.46	1.10	4	0.80
Engaging in experiential learning in the course.	3.16	0.94	3	3.64	1.10	4	0.51
Calling upon your personal values to motivate the study of the problem or problems.	3.16	0.99	3	3.31	1.20	3	0.15

The table below (Table 6) shows the student post-course mean ratings of the interdisciplinary items grouped by their instructor's rating of emphasis on studying an interdisciplinary problem. Generally, higher levels of instructor emphasis are aligned with higher post-course ratings of the items. Only one, *connecting your personal experience to the course problem or problems*, fails to reach statistical significance at the $\alpha = .01$ level when analyzed by a between groups Analysis of Variance. Moreover, pair-wise testing using Tukey's HSD procedure shows that the major emphasis means are significantly higher than the minor emphasis means. For some items, the student means increase in orderly and significant increments. The results indicate that student evaluations reflect faculty efforts to teach interdisciplinary elements.

Table 6.			
Student survey mean ratings grouped by their instructor's pre-course rating of emphasis on an interdisciplinary problem.	Minor	Moderate	Major
Working on problems that have no clear solution.	3.11	3.31	3.42
Connecting your personal experience to the course problem or problems.	3.36	3.52	3.53
Learning that the use of disciplinary knowledge needs to be accurate and fair.	3.43	3.67	3.64
Receiving assigned coursework from more than one discipline or area of study.	3.11	3.48	3.64
Learning that disciplines may approach problems in different and sometimes conflicting ways.	3.32	3.85	3.83
Using instruments or materials borrowed from another discipline or field of study.	2.76	3.29	3.37
Working with students who major (or probably intend to major) in other disciplines or fields of study.	3.20	3.56	3.55
Learning to find similarities and differences between disciplines or fields of study.	3.23	3.53	3.59
Working on defining a problem and refining the definition while solving the problem.	3.26	3.46	3.45
Working on a problem that requires integrating ideas from two or more sciences.	3.00	3.49	3.71
Studying an interdisciplinary problem.	3.03	3.50	3.71
Spending the entire course on one or a few problems.	2.47	2.99	3.19
Working on a problem that requires integrating ideas from both science and non-science disciplines.	2.94	3.41	3.42
Attempting a complete understanding of a complex problem.	3.37	3.62	3.78
Learning to ask "big questions" that implicate more than one discipline in a solution.	3.23	3.70	3.73
Talking with faculty members from other disciplines or fields of study.	2.82	3.41	3.43
Reading primary literature from multiple disciplines or fields of study.	2.75	3.33	3.32
Learning to translate the specialized language of a discipline into the language of other disciplines.	2.84	3.29	3.37
Learning about two (or more) disciplines so that new insights emerge from considering them together.	2.88	3.36	3.53
Judging the relative contribution of disciplines to the solution of the problem.	2.77	3.30	3.29
Creating new metaphors, analogies, or models to understand problems.	3.02	3.33	3.34
Learning computer modeling of complex systems.	2.48	3.26	3.29
Studying problems with multiple causes that operate simultaneously and interactively.	3.10	3.53	3.53
Engaging in experiential learning in the course.	3.50	3.73	3.65
Calling upon your personal values to motivate the study of the problem or problems.	3.06	3.37	3.32

Benefits of the experience

The RISC survey follows the SURE and CURE surveys in asking students to evaluate 21 items described as benefits of the experience. The items, offered in the post-course survey, are introduced with this comment: "In this section of the survey you will be asked to consider a variety of possible benefits you may have gained from your research experience." Each item is rated on a scale of 1 (no gain or very small gain) to 5 (very large gain). Students may opt out of answering any item that does not apply to their experience.

The initial motive to include these items, sometimes informally referred to as the SURE items (because they first appeared in the SURE survey), was exploratory. The resulting data were often described alongside either SURE or CURE statistics to permit the reader to ponder the similarities and differences between the student experiences. In Table 7 below are the means from the CURE survey (17,680 cases from 2015 through 2018) and the RISC survey.

Table 7. Mean rating of benefits for the CURE survey and the RISC survey.

	CURE		RISC	
	Mean	**SD**	**Mean**	**SD**
Clarification of a career path	3.13	1.22	2.92	1.28
Skill in interpretation of results	3.70	0.98	3.43	1.08
Tolerance for obstacles faced in research process	3.67	1.00	3.38	1.10
Readiness for more demanding research	3.59	1.04	3.34	1.10
Understanding how knowledge is constructed	3.60	1.01	3.34	1.08
Understanding the research process	3.66	1.06	3.39	1.13
Ability to integrate theory and practice	3.61	1.01	3.38	1.07
Understanding how scientists work on real problems	3.75	1.00	3.51	1.07
Understanding scientific assertions require evidence	3.78	1.01	3.49	1.13
Ability to analyze data and other information	3.86	0.96	3.57	1.08
Understanding science	3.77	0.99	3.44	1.10
Learning ethical conduct	3.38	1.18	3.28	1.23
Learning laboratory techniques	3.86	1.05	3.30	1.29
Ability to read and understand primary literature	3.56	1.12	3.24	1.23
Skill in how to give an effective oral presentation	3.36	1.23	3.05	1.27
Skill in science writing	3.53	1.13	3.18	1.22
Self-confidence	3.43	1.17	3.10	1.23
Understanding how scientists think	3.60	1.05	3.24	1.11
Learning to work independently	3.48	1.13	3.17	1.19
Becoming part of a learning community	3.61	1.09	3.41	1.16
Confidence in my potential as a teacher	3.11	1.27	2.83	1.31

The CURE means are generally higher than the RISC means, possibly reflecting the selection of courses that use the CURE. As the CURE survey became more popular, course instructors tended to select it because they were attempting to teach a course with an embedded research component. Often the outcome was a profile of benefits that resembled those of a dedicated research experience (as measured by the SURE survey). Courses that attempt an interdisciplinary approach often use pedagogic techniques that resemble those of course embedded undergraduate research experiences, but the resemblance is not necessary. It is not surprising that the RISC means are more modest than the CURE means. The result will depend on the nature of the individual course being evaluated.

Overall Evaluation

As with other surveys, RISC respondents are given the opportunity to make some general evaluations of their course experience. The four statements in the table below are rated on a scale of 1 (strongly disagree) to 5 (strongly agree). Note the focus on science and scientific research, which may be appropriate for some but not all courses. The mean ratings for the CURE survey (17,680 cases from 2015 through 2018) are provided for comparison.

Overall Evaluation (Table 8)	**CURE**		**RISC**	
	Mean	**SD**	**Mean**	**SD**
This course was a good way of learning about the subject.	4.15	0.93	4.22	0.93
This course was a good way of learning about the process of scientific research.	4.22	0.90	3.96	1.00
This course had a positive effect on my interest in science.	4.01	1.07	3.99	1.00
I was able to ask questions in this class and get helpful responses.	4.21	0.94	4.26	0.90

The four items tend to be correlated with each other, and also tend to correlate with the items in the list of benefits. They do not differentiate the degrees of interdisciplinary emphasis in a course as measured by faculty ratings; rather, they seem to signal the student's holistic response to the course's effectiveness.

Opinions About Science (positive and negative perceptions)

Beginning with the CURE survey and continuing into the RISC survey, items regarding the student's attitude toward science were included to gauge what various commentators might call attitude, engagement, or epistemological attitudes. The RISC survey items are subset of a larger set of items that were included in the CURE survey. Occasional exploratory factor analyses of annual data sets uncovered a robust result. The five items shown in the table in italics and shading loaded on one factor (reflecting positive perceptions of science) while the other six items loaded on a second factor (reflecting negative perceptions of science). Thus, in addition to examining student responses to each item it is interesting to sum the items on a factor and use the resulting scale to examine positive perceptions and negative perceptions of science.

Table 9. Opinions about science	PreCourse			PostCourse			Difference
	Mean	SD	Median	Mean	SD	Median	(in SD units)
Even if I forget the facts, I'll still be able to use thinking skills learned in science	4.26	0.69	4	4.29	0.70	4	0.04
The process of writing in science is helpful for understanding scientific ideas	4.09	0.73	4	4.11	0.76	4	0.03
I wish science instructors would just tell us what we need to know so we can learn it	2.82	1.01	3	2.74	1.11	3	-0.08
Creativity does not play a role in science	1.75	0.80	2	1.90	1.01	2	0.20
Science is not connected to non-science fields such as history, literature, economics, or art	1.80	0.86	2	1.95	1.07	2	0.18
I get personal satisfaction when I solve a scientific problem by figuring it out myself	4.28	0.77	4	4.26	0.76	4	-0.03
Science is essentially an accumulation of facts, rules, and formulas	2.86	0.98	3	2.77	1.05	3	-0.09
I can do well in science courses	3.99	0.78	4	4.06	0.78	4	0.09
There is too much emphasis in science classes on figuring things out for yourself	2.58	0.84	3	2.64	0.96	3	0.07
Explaining science ideas to others has helped me understand the ideas better	4.24	0.77	4	4.24	0.73	4	0.01
If an experiment shows that something doesn't work, the experiment was a failure	1.61	0.75	1	1.72	0.97	1	0.14

Analysis of these items as pre- and post-course items reveals that there is inconsistent change in the responses from pre- to post-course. Most of the courses being evaluated are completed in one term; there is an unsettled literature regarding how much perceptions change after one course. While change in these perceptions is not consistent, the relation of the perceptions to other variables in the survey is fairly robust. Suppose we sum the five items in the positive category to yield one score for each student, and then sum the six items in the negative category to yield a second score for each student. In the table below (Table10) we find significant bivariate correlations between these two perception scales and other student evaluation variables. Generally, a higher score in positive perception correlates directly with self-reported outcomes while a higher score in negative perception correlates with other variables either inversely or not at all.

Relations between variables in the student survey (Table 10)

Variables	Spearman Correlation
Positive perception: pre and post	0.53
Negative perception: pre and post	0.56
Positive and Negative perception (pre)	-0.43
Positive and Negative perception (post)	-0.37
Positive perception and average benefit*	0.43
Positive perception and good way of learning subject	0.35
Positive perception and process of research	0.32
Positive perception and interest in science	0.43
Positive perception and asking questions	0.39
Negative perception and average benefit*	0.07
Negative perception and good way of learning subject	-0.14
Negative percepton and process of research	0.03
Negative perception and interest in science	-0.13
Negative perception and asking questions	-0.17

*Average benefit is the average of the 21 benefits. These correlations are with post-course survey information. All correlations are significantly differient from 0 at the alpha = .05 level except one: the correlation between negative perception and the evaluation of learning the process of research.

Conclusion

The RISC survey assumes no a priori definition of interdisciplinary courses. The RISC survey proceeds on the assumption that interdisciplinarity emerges from the connection between what the course instructor intends and what the students learn. Results, such as those highlighted in Table 6, suggest a set of inter-related processes and outcomes that work toward an empirical description of what is meant by an "interdisciplinary course."