Faculty practices & faculty outcomes of undergraduate research

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Acknowledgments

- Heather Thiry, Anne-Barrie Hunter, Elaine Seymour, Ginger Melton
- Tim Weston, Chuck Hayward, Sarah Wise
- Joanne Stewart (Hope C.), Erin Dolan (UT Austin), Sara Brownell (Arizona State), Lisa Auchincloss Corwin (U. N. Carolina), Tom Higgins (Harold Washington C.), Gwen Lawrie & Susan Rowland (U. Queensland)
- U.S. National Science Foundation; Howard Hughes Medical Institute; Research Corporation; Noyce, Sloan & Spencer Foundations

Overview of presentation

The fundamental tension of apprentice-model UR

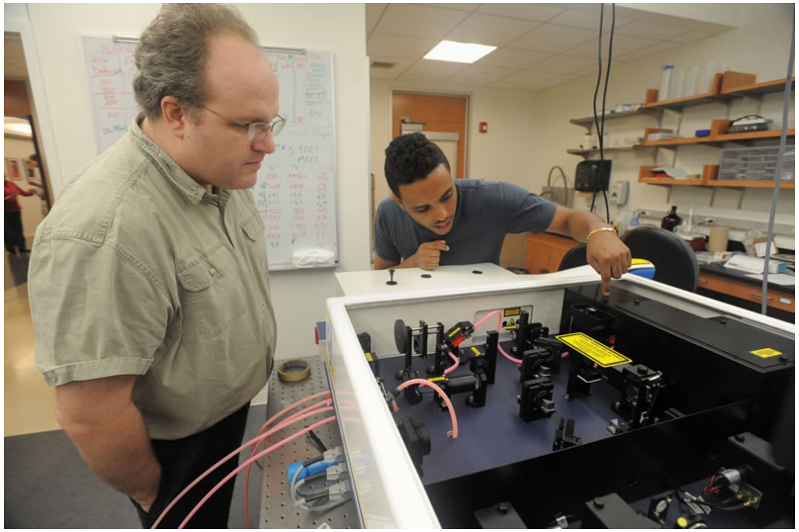
How advisors teach through UR

Costs and benefits for faculty advising UR

Implications for research-based laboratory courses as an alternative

Defining apprentice-model UR

While an investigation is… focused on actively engaging learners in authentic scientific inquiry, apprenticeship goes one step further and situates this investigation in the context of… a particular scientist's research agenda. Here, the apprentice is under an expert's tutelage, using the scientist's lab and equipment, doing the science that contributes to the scientist's work, and doing the science in which the scientist (and potentially the apprentice) has a vested interest.



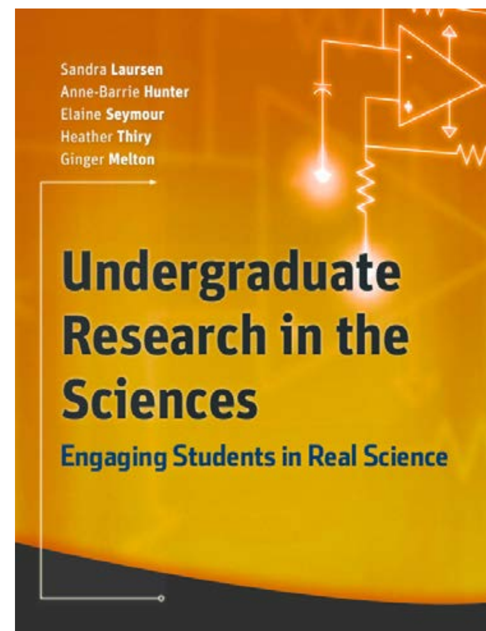
This experience allows the learner to gain insights into the communal nature of science and may facilitate the learner's adoption of ways of perceiving and interacting with the world that are consistent with those of real scientists.

Barab & Hay, 2001, p. 71

E&ER's research & evaluation work on UR

- 4-year study of undergraduate research at four liberal arts colleges; >350 interviews in multiple disciplines (students & faculty)
- evaluation studies of UR programs at 2 research universities & 1 national lab; >350 interviews, >150 survey responses (students & faculty)
- evaluation study of UR advisors' experiences at 1 research university (30 faculty, postdocs, grad students)
- development & validation of *URSSA*, the *Undergraduate Research Student Self-Assessment*
- evaluation of research-based courses (CUREs, ALUREs) in US and Australia

URSSA
Undergraduate Research Student Self-Assessment



I: What do you think umm, so, so you've talked, umm, we've talked mostly so far about the, the skill of building a proof and writing it beautifully. Umm, what are students learning about the nature of mathematics or how mathematicians work? Do they get a glimpse of that from this kind of work that is different than a lecture based class?

M: Yeah, I guess they would because umm, the idea is well, a mathematician is really trying to answer questions or like ask, basically they're trying to phrase, phrase a question in the right way so that you can answer it. Umm, and I think that that kind of does come across. Umm, so and I guess there's, it's a way to model umm, kind of going up against something that's unknown right. You're not reading, you're not trying to understand a, a proof that's written up in a book, you're trying to create something new. Umm, which I guess the bar is, is lower but that's where it should be right, because they haven't done it before. Umm, but yeah it does, I guess it does simulate those kind of things and just the idea that you have to fall back on first principles in order to solve something and just build something up out of nothing that can, that's very similar to what I'm trying to do in grad school yeah.

I: So they get a little taste at least of the research process?

M: Yeah

I: They're not discovering new math?

M: Yeah they're not discovering new math right, they're not solving questions that no one else has solved before but, they're solving questions that no one in the class has solved before so.

I: Right, ok. What other kinds of umm, skills or knowledge do you see them developing?

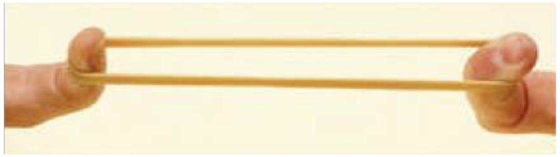
M: I guess umm, that there was, umm, I guess the one thing that they, that they had to work on was definitely presentations right? So I guess on day one umm, you know we were just starting out and so the professor, the instructor just went over the syllabus and I went up and gave a bad presentation. Umm, so it was wrong and it was poorly written and bad right, so, so we kind of felt like that was a good place to start.

I: A little theatre.

M: Yeah, just because immediately they started critiquing what was going on and, and so people sort of started to realize what the bar was, like where we were setting the bar but in some sense even that, they were kind of coming up with themselves so they understand, they have this understanding of, of what standards to impose. Umm, and then I guess just the fact that, you're, you're learning something in great depth but also you're learning it to the point where you can teach it, umm, and speak articulately about the complex process which I guess is one of the most lucrative things that you can ever do. Like one of the most lucrative skills that you can ever attain. Umm, so I'd say that that, you know being able to speak articulately about something is, is a skill they develop that, you know, that students in a calc course just probably don't always umm, develop or it's really hard to get that to work in a large lecture environment, to get the students, you know you can get them to write something up and maybe solve problems in

Analyzing interview data

Inherent in the practice of UR is a fundamental tension

student education  science scholarship

Traditional outcome measures:

student goes to grad school

student-coauthored pubs & presentations

learning & understanding
- skills
- science concepts
- how science works

personal growth
- confidence
- responsibility
- scientific identity

career decision-making

student…
- works in industry
- becomes a teacher
- goes to med school
- carries scientific literacy into real life
- instills love of science in his own children

Seymour et al., 2004; Laursen et al. 2010

Laursen et al., 2012; Laursen 2015

High consensus on general outcomes of UR

+ Students' gains from UR

- skills—e.g. lab work, communication
- conceptual knowledge & linkages in their field
- ability to do intellectual & practical work of science (inquiry, thinking like a scientist)
- growth in confidence; adopting a science identity (becoming a scientist)
- preparation for a career or graduate study in science
- clarity in making career & educational choices

+ Critical aspects of engagement in research

e.g., having responsibility, presenting one's work to others

- Distributed & variable nature of UR offers assessment challenges

- confidence, identity change, career clarity best measured by self-report
- knowledge & skills easiest to measure, but least value-added
- 'thinking like a scientist' gains depend strongly on specifics of field & project

- Institutional & self-selection is a problem in many studies

see e.g. *Eagan et al., 2013; Linn et al., 2015; Estrada, 2015; Laursen 2015*

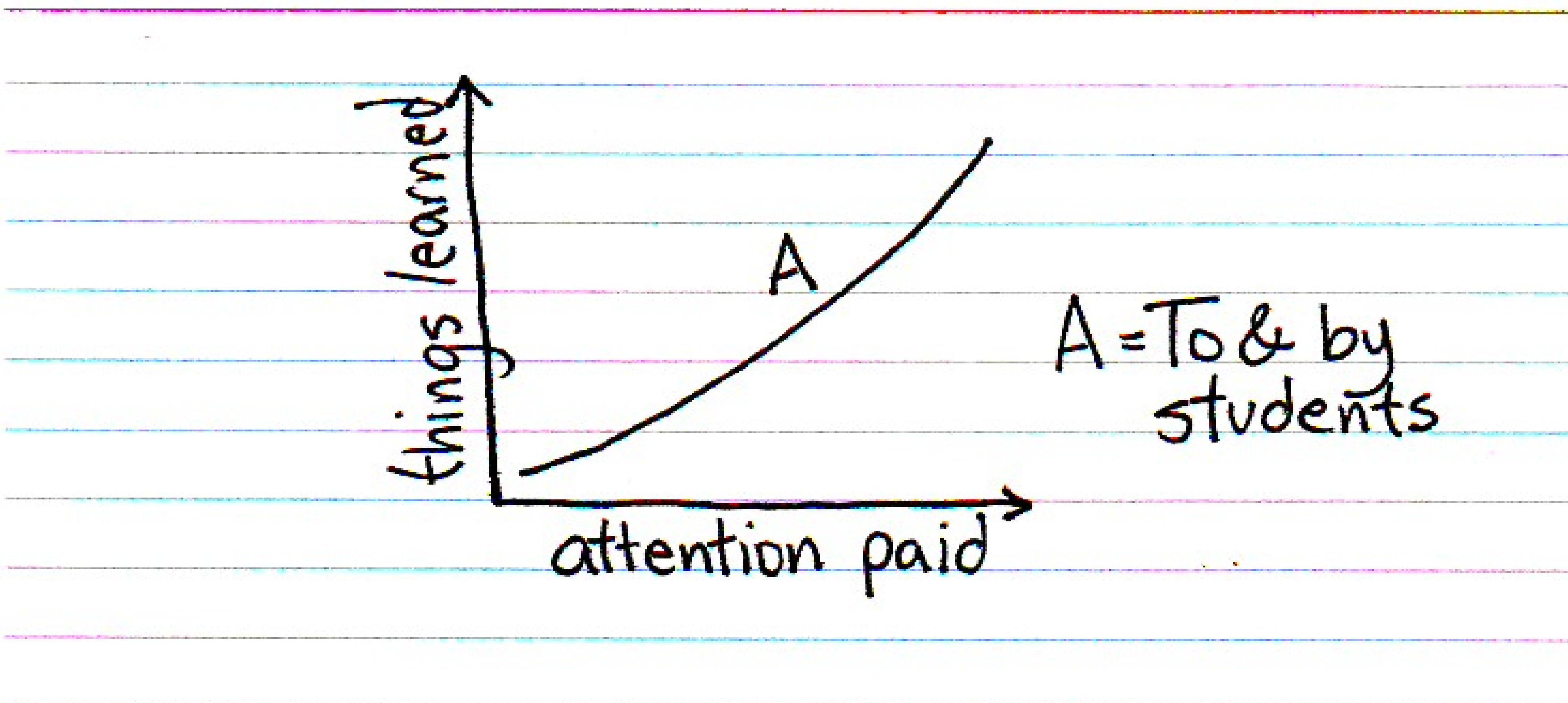
How do these good outcomes emerge?

Student reports of their interactions with UR advisors

Professional socialization	Intellectual support to carry out the project	Personal or emotional support
Setting expectations about role & responsibilities *failure mode: lack of direction* Disciplinary anchoring: concepts & tools of project, big picture connections *failure mode: lack of sense-making, understanding* Guiding & modeling scientific behaviors *failure mode: lack of independence*	Knowledge & comprehension Application & analysis *failure mode: lack of intellectual growth* Synthesis & evaluation *failure mode: many students not ready for this; advisors miss some opportunities*	Open, accessible, patient, respectful Receptive to students' ideas; student feels taken seriously *failure mode: lack of meaning, lack of enjoyment*

Interview data from 110 students in 4 programs -- *Thiry & Laursen, 2011*

Student outcomes correlate with quality of mentoring



Jessica Hagy, thisisindexed.com

How do advisors teach in UR?

It's very much a teaching thing—I'm always thinking of what I want them to come away with and how I can get them there.

A carefully scoped but authentic scientific project

It's gotta be answering a question that the scientific community—my little subset—really wants to know the answer to, and wants to know it now.

Teachable moments arising naturally out of real problems

I don't know the answers, they don't know the answers. We're a bunch of smart people sitting in a room trying to figure some things out.

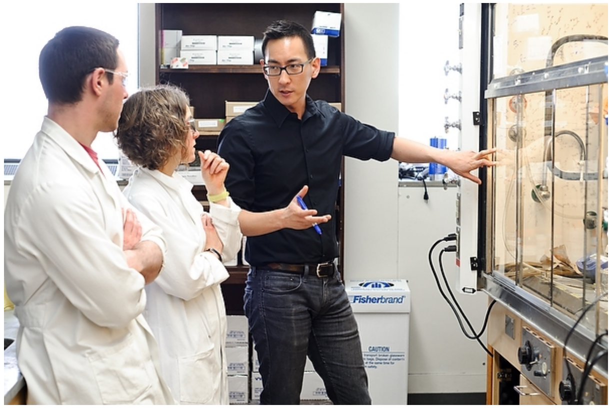
Side-by-side collegial work, informal & approachable style

Modeling how to cope with uncertainty & failure

Carefully timed interventions when required

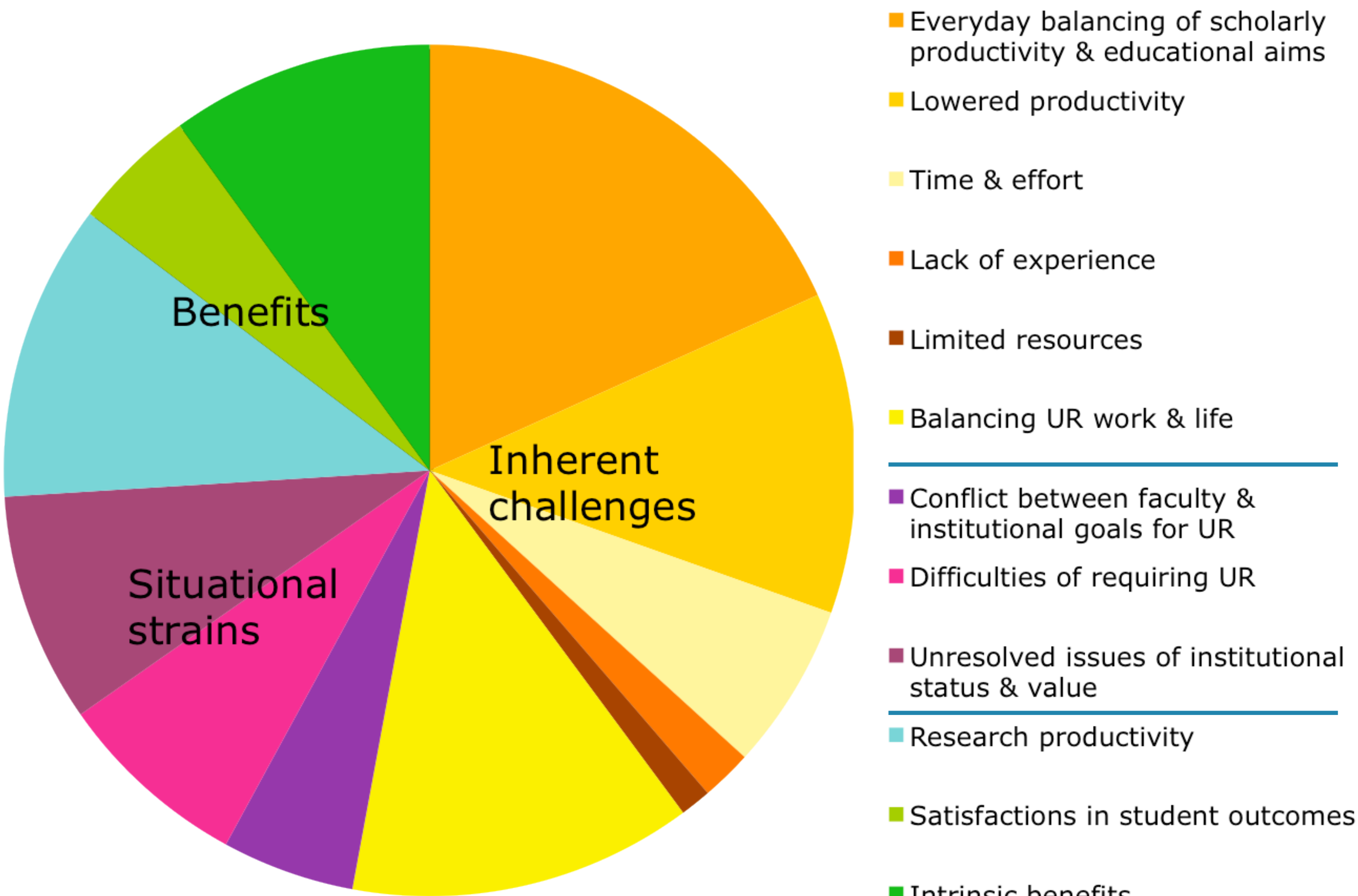
Effective use of the research group

as sounding board, safe practice space, source of training & collegiality



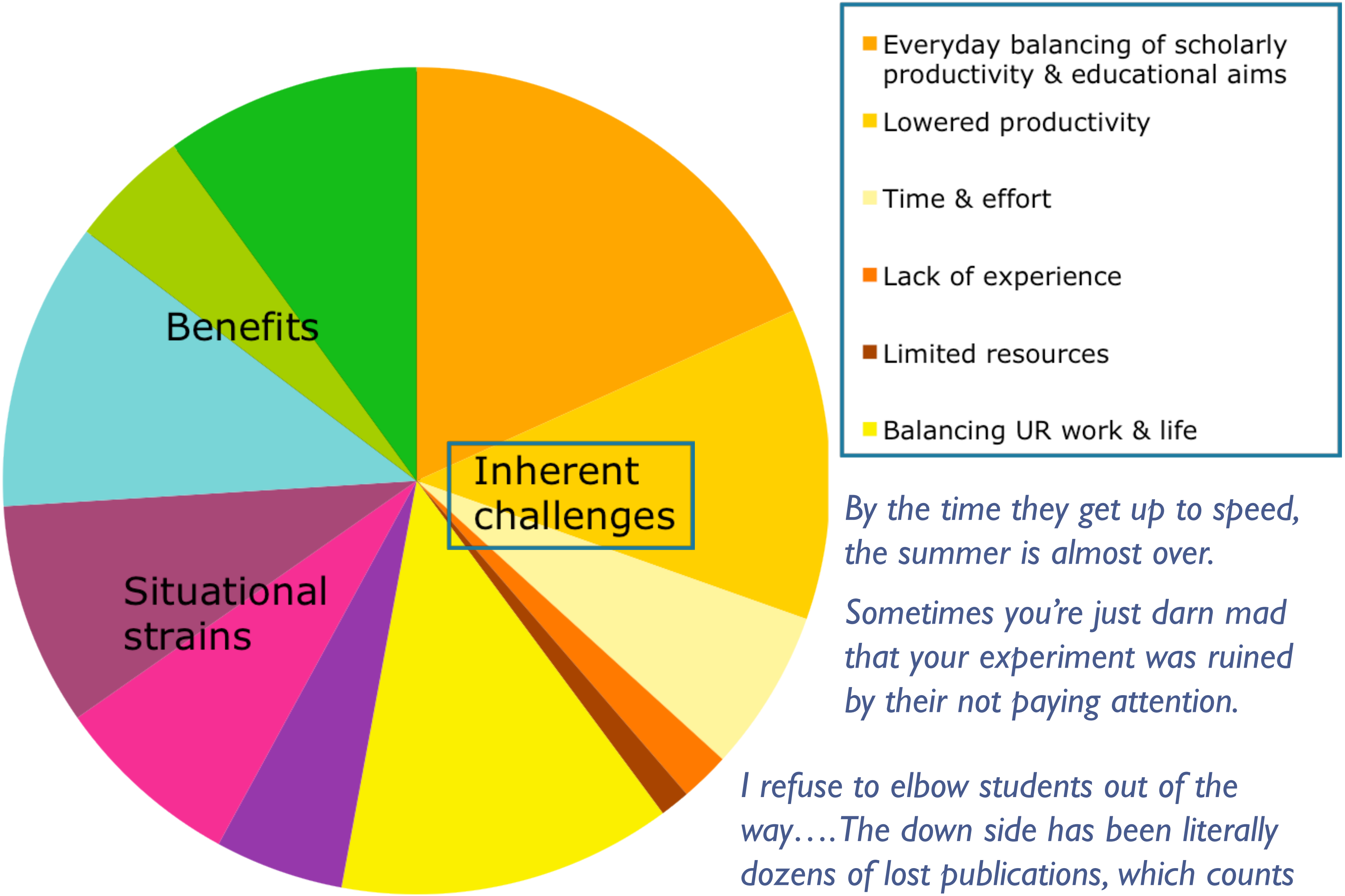
Laursen et al., 2010

What are the costs & benefits to faculty?



2544 coded comments from 80 faculty interviews – *Laursen, Seymour & Hunter 2012*

Inherent challenges of doing research with students

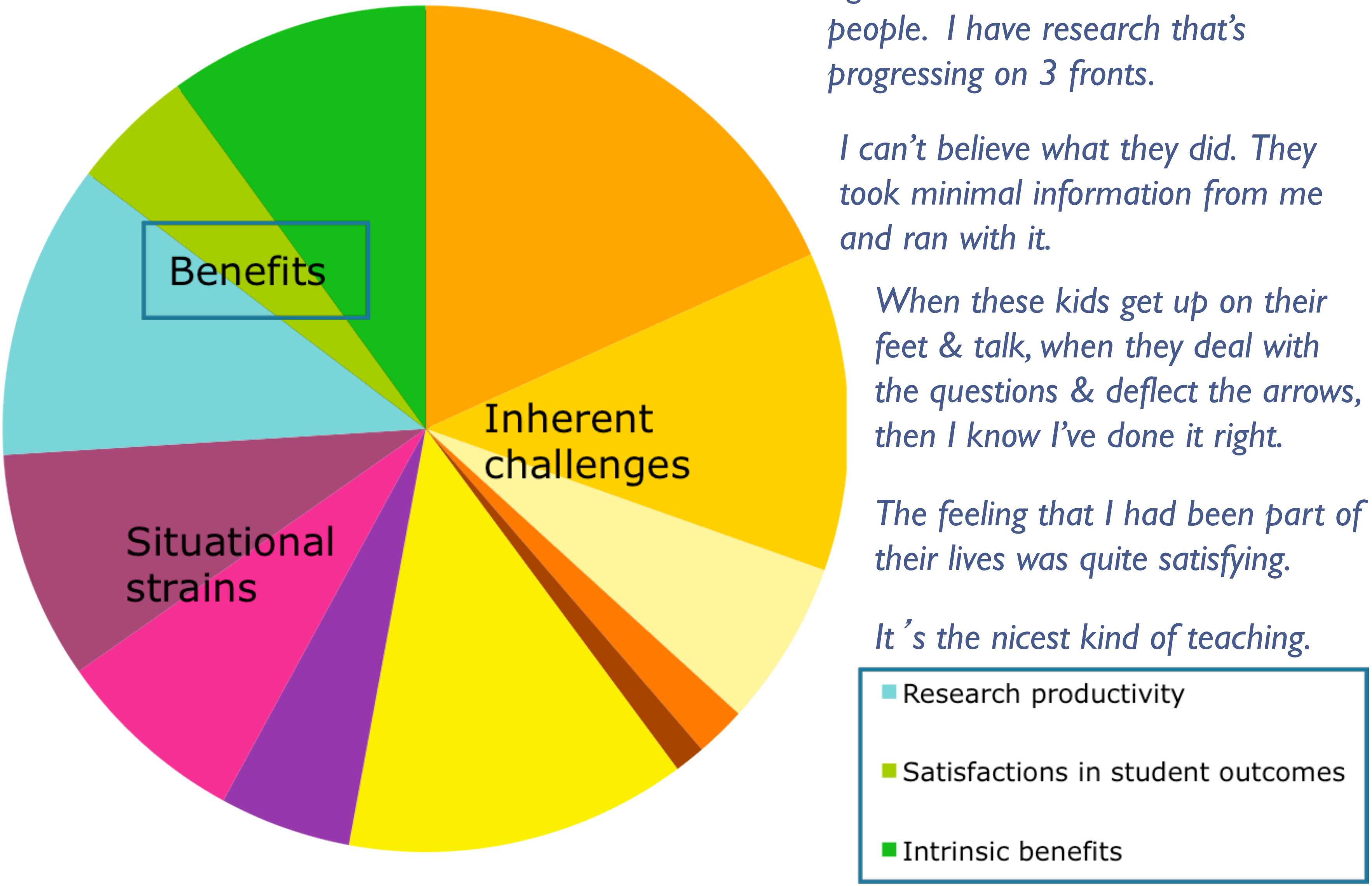


By the time they get up to speed, the summer is almost over.

Sometimes you're just darn mad that your experiment was ruined by their not paying attention.

I refuse to elbow students out of the way….The down side has been literally dozens of lost publications, which counts against me despite the rhetoric.

Benefits of doing UR



I get to work with some damn smart people. I have research that's progressing on 3 fronts.

I can't believe what they did. They took minimal information from me and ran with it.

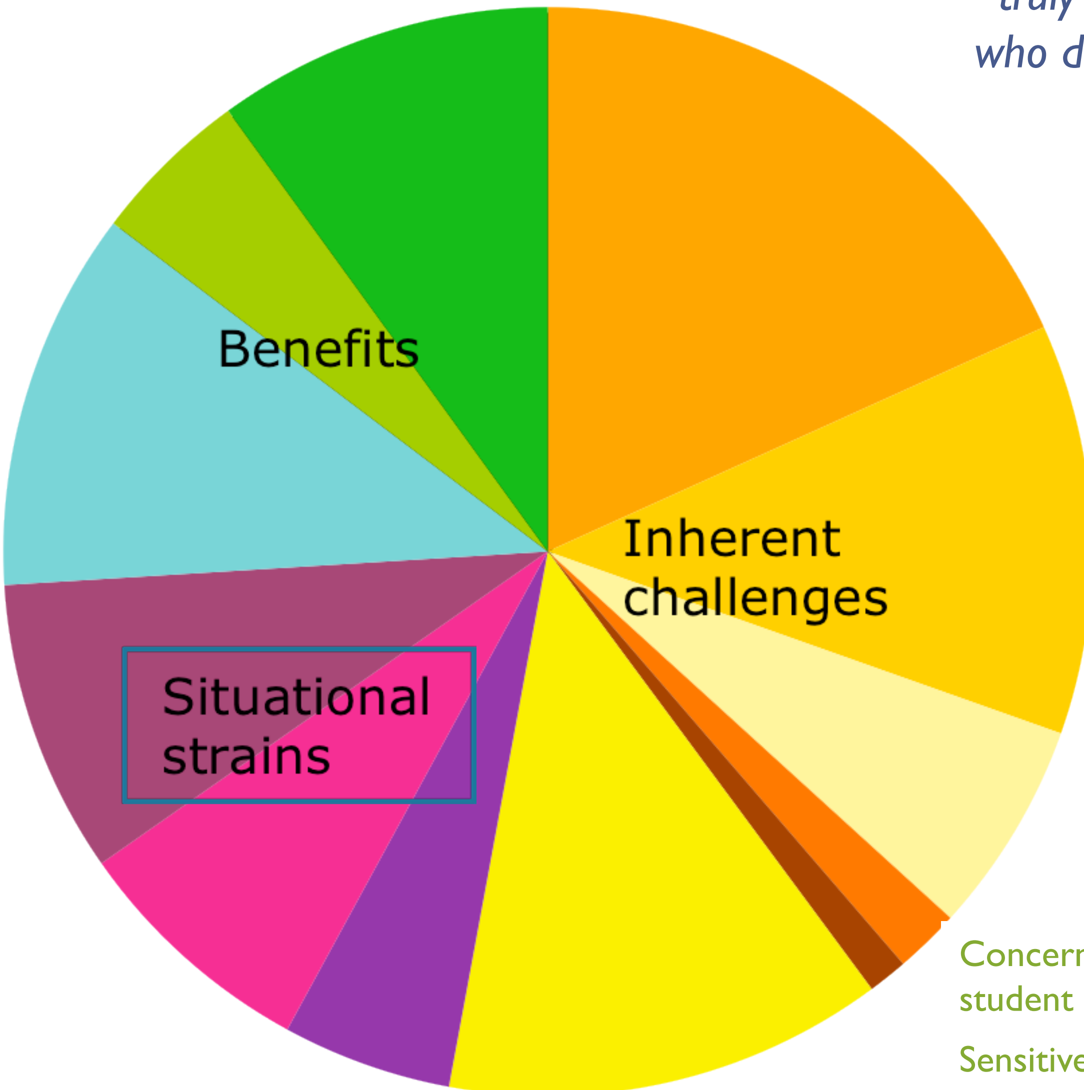
When these kids get up on their feet & talk, when they deal with the questions & deflect the arrows, then I know I've done it right.

The feeling that I had been part of their lives was quite satisfying.

It's the nicest kind of teaching.

Shift from instrumental to intrinsic motives over time -- *Hayward, Laursen, & Thiry in prep.*

Extra strains due to institutional pressure to expand UR



"truly miserable summers" with students who don't want to be there

We pressure our own faculty to accept students for the summer… A lot of people have results that they've never written up, experiments they would have finished if they'd just take a summer off to do it.

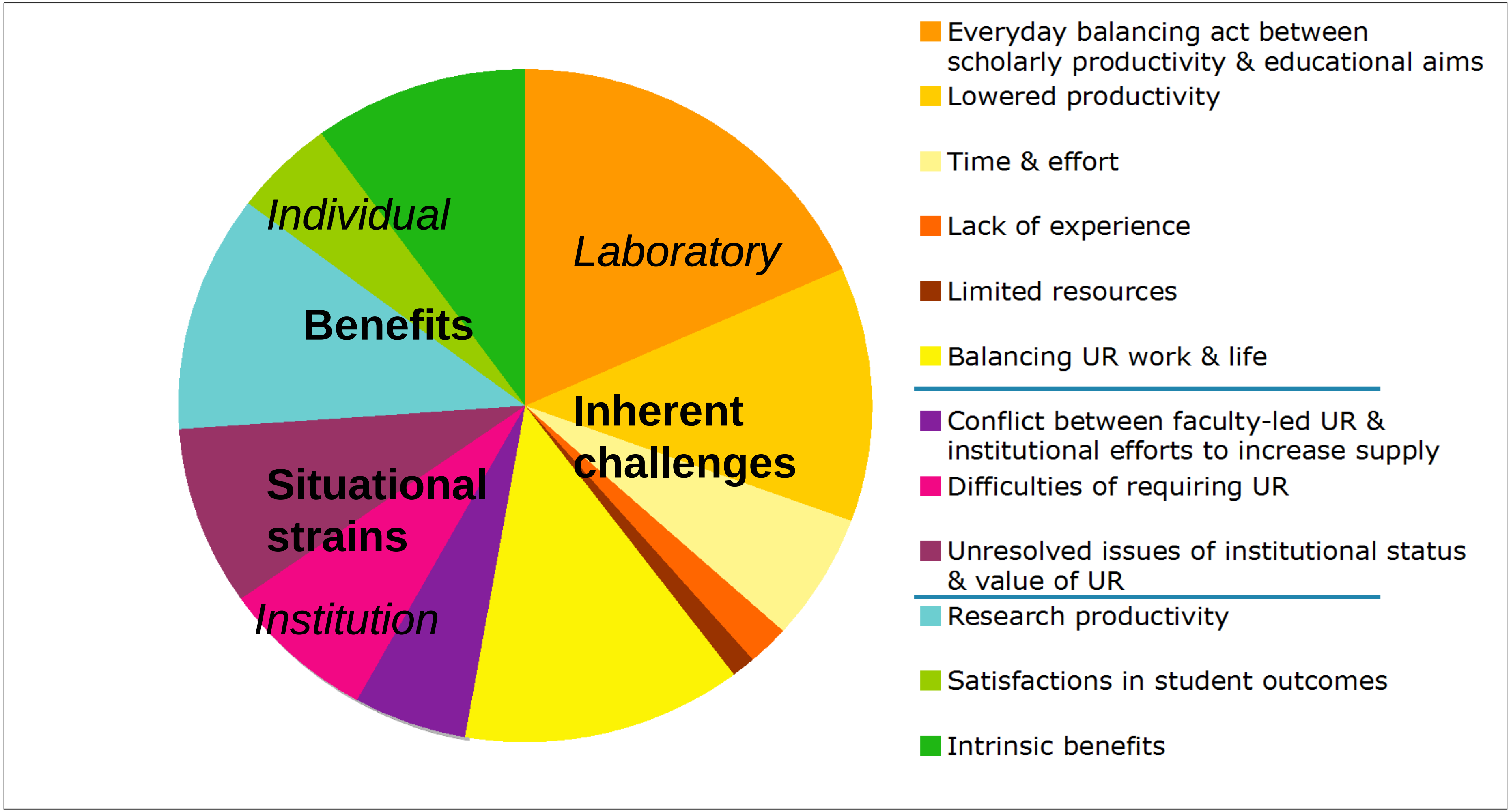
- Conflict between faculty & institutional goals for UR
- Difficulties of requiring UR
- Unresolved issues of institutional status & value

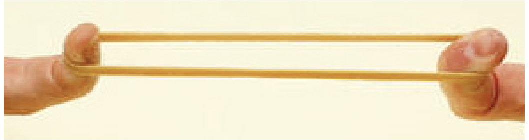
Concerns about risks to authenticity & quality of student experience

Sensitive balance between educational & research objectives

Issues of control over the content & methods of UR

At issue: Locus of control



student education  faculty scholarship

Apprentice-model UR works

student education  science scholarship

Benefits of UR to students

are significant & distinctive; a form of apprenticeship.

Scientific authenticity is essential to achieving these outcomes

Research problem, methods, standards emerge from faculty scholarship.

Faculty teach through situated problems or teachable moments.

Costs and benefits of UR to faculty are individually managed

as long as faculty retain control of whether, when & how they do UR.

But extra strains arise when institutions seek to extend UR to more students.

*Apprentice-model UR grows out of the culture & practices of **science…***

*How do we build research experiences into **organized formal education?***

Are CUREs a CURE-all?
The rise of course-based UR experiences

Institutional & funder pressure to involve more students in more/earlier UR

Concerns over equity of access to a scarce resource

→ High interest in "research-based courses" or "course-based UREs" or "course-embedded research" as substitutes for apprentice-model UR

Proposed elements of a CURE

1) There is an element of discovery; outcomes are not predetermined
2) Students learn & use scientific practices
3) Iteration is built in as a source of learning (trying, failing, critiquing)
4) Collaboration is built in as a source of learning (skills, deeper understanding, metacognition)
5) The topic is broadly relevant beyond the class (to science knowledge, community); offers opportunity for impact or action

Corwin Auchincloss et al., 2014

‘Autonomy & distress’: 2 examples from research-based courses

Scheme after Wilson, Howitt & Higgins, 2015	Specific skills & knowledge arising from project work;	Capacity to carry out scientific practices	Habits of mind, ways of thinking	Sense of self as scientist
		Thinking like a scientist		
1 **Value-added kinds of learning that emerge from doing research**	Project-specific procedural skills & techniques General scientific skills (collaborate, lab notebook) Understanding everyday work of research (slow pace, need for care)	Skills of inquiry: (design expts, analyze data, make inferences) Understanding nature of science knowledge, how it is constructed	Critical thinking & problem-solving, applied in context Independent thinking Skill in synthesizing knowledge	Sense of ownership Tolerance of failure & frustration Confidence to do research, contribute Collegial relationships with faculty & peers
Extensions of conventional learning	Understanding concepts Interpreting statistical data			Knowledge of social workings of science; science as profession

2 *There seems to be **a tussle, a choice to make, between authenticity and ownership**. The more you need the supervisor to help with the science—because they can do it fast, make the decisions—then the students can get some results. If you give students the ownership, they won't necessarily find the gap or design an appropriate method to fill the gap. So then the experience is more about inquiry, the results are not novel—it's **less authentic in the outcomes but more authentic in the scientific processes**.*

***If you want them to produce publishable data, you have to control too much. You can't do that if you want them to learn something—then you just have a bunch of little robots**. They do need a real-world context. They need to think it's important, whatever they are doing—even if it is pretty heavily controlled.*

*It is possible to over-support students—but you can't do that if you want them to do something authentic. … The **sense of being lost** is really important.*

ALURE PROJECT

'Autonomy & distress': 2 examples from research-based courses

Scheme after Wilson, Howitt & Higgins, 2015	Specific skills & knowledge arising from project work;	Capacity to carry out scientific practices (Thinking like a scientist)	Habits of mind, ways of thinking (Thinking like a scientist)	Sense of self as scientist
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Not much distress, but not enough autonomy

There seems to be ***a tussle, a choice to make, between authenticity and ownership****. The more you need the supervisor to help with the science—because they can do it fast, make the decisions—then the students can get some results. If you give students the ownership, they won't necessarily find the gap or design an appropriate method to fill the gap. So then the experience is more about inquiry, the results are not novel—it's* ***less authentic in the outcomes but more authentic in the scientific processes***

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It is possible to over-support students—but you can't do that if you want them to do something authentic. …
The ***sense of being lost*** *is really important.*

Raise autonomy, stop before distress is acute

Why is this a problem?

student education  science scholarship

1) For students: "Research" may not incorporate good inquiry

2) For instructors: More constraints of student time, lab costs, scaling up

- Must be more selective about the learning goals
- With little knowledge of how outcomes may arise, in what order
- With instructors not necessarily experienced in inquiry teaching

Questions for research & practice on research-based education

What features distinguish UR from CUREs & other investigative learning?

- What makes it "research"? (and how much does that matter?)
- How do elements of scholarly authenticity relate to student outcomes?
- What aspects of "research" fit (or not) within course constraints?

How do we design, scaffold & sequence experiences that support "thinking like" and "becoming" a scientist?

- How do we engage colleagues in doing this? (stealth PD??)

How else can we address equity of access? (implicit bias education??)

What are the costs & benefits to faculty of implementing this (any) innovation?

- Spread & sustainability of the innovation
- Recruitment & diversity of future professoriate
- Traditions of autonomy & academic freedom
- Status issues around "research" vs "inquiry teaching"