Target Inquiry: Transforming In-Service Teacher Professional Development and Instruction in High School Chemistry

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Session Goals

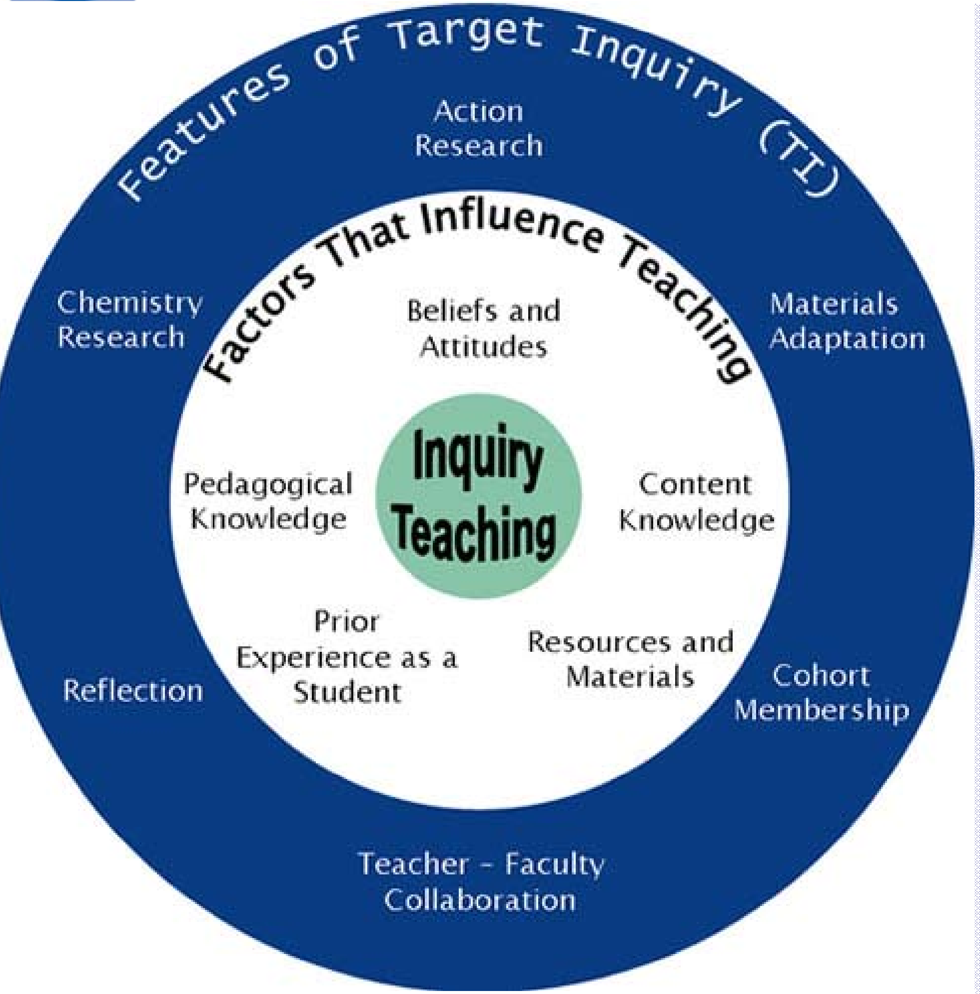
- Share the results of the study of *Target Inquiry* (TI) with the DR K-12 community.
- Generate discussion about shifting teacher PD toward theory and data-driven models and away from brief "make-and-take" experiences.
- Solicit ideas regarding the logistics of scale-up and dissemination of PD models and how the DRK-12 community can have a coordinated impact on a national level.

Problem

Complete references available on TI web site

	Proven Practices	Reality
High School Chemistry Instruction	Primarily <u>inquiry-based</u> (National Research Council, 1996)	▪ Traditional lecture/discussion ▪ Occasional verification lab activities (Smith, 2002)
High School Teacher Professional Development	▪ Sustained ▪ Coherent ▪ Promote active learning ▪ Content-focused ▪ Pedagogy-focused (Garet, Porter, Desimone, Birman, & Yoon, 2001;NRC, 1996)	▪ Short-term ▪ Patchy ▪ Has little influence on instruction ▪ Does not affect student learning ▪ Not supported by schools (American Association of Colleges and Universities, 2001)

Target Inquiry (TI) Model and Program



- Focused on learning as a process of individual construction and enculturation into practices of the culture (Cobb, 1994)
- Integrates activities shown to impact teachers and their students (Berlin, 1996; Keys & Bryan, 2001; SWEPT, n.d.)
- Supports activities with features identified as key for effective PD (Garet, Porter, DeSimone, Birman, & Yoon, 2001)

Program Goal: Improve the quality and frequency of inquiry-based instruction in high school science classrooms

Berlin, D. (1996). AERA conference paper.
Cobb, P. (1994). *Educational Researcher,* 23(7), 13-20.
Garet, M., et al. (2001). *Amer. Ed. Res. Journal*, 38, 915-94.
Keys, C. & Bryan, L. (2001). *JRST*, 38(6), 631-645
SWEPT (n.d.). http://www.sweptstudy.org/manuscript.pdf

Theoretical Framework and Assumptions

Social Constructivism

- Learners construct knowledge based on personal experiences and the negotiation of those ideas with peers and "experts" (Driver, 1995; Vygotsky, 1978).

Teachers' Beliefs

- Teaching and learning: These must change before they are ready to change their teaching practices.
- Scientific inquiry: Few teachers have authentic research experience that they can use to develop their understanding of science inquiry.

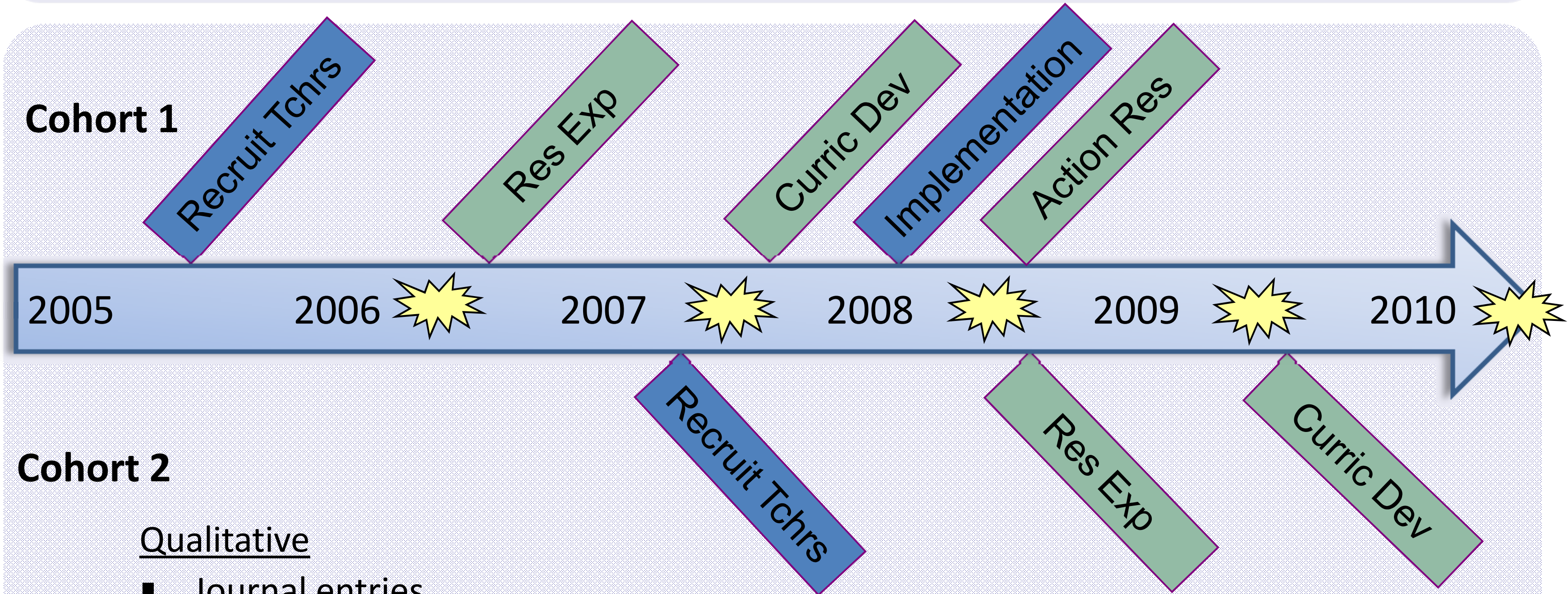
Driver, R. (1995). Constructivist approaches to science teaching. In L.P. Steffe & J. Gale (Eds.),Constructivism in education (pp. 385-400). Hillsdale, New Jersey and Hove, UK: Lawrence Erlbaum Associates Publishers.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes, Cole, John-Steiner Scribner, & Souberman (eds.), Harvard University Press, Cambridge, MA.

Research Questions

- How do the three core experiences (**chemistry research, materials adaptation, and action research**) impact in-service high school teachers'
  (i) content knowledge in chemistry;
  (ii) attitudes and beliefs about scientific inquiry and self-efficacy; and
  (iii) classroom instructional methods?
- How does teacher participation in TI affect student achievement?

Longitudinal Mixed-Methods Design



<u>Qualitative</u>

- Journal entries
- Semi-structured interviews
- ITB (Harwood, Hansen, & Lotter, 2006)
- Course artifacts
- Observer field notes

<u>Quantitative</u>

- ACS exams (for teachers and students)
- RTOP (Sawada et al., 2002)

Harwood, W. S., Hansen, J., & Lotter, C. (2006). Measuring teacher beliefs about inquiry: A blended qualitative/quantitative instrument. *Journal of Science Teacher Education*, *15*(1), 69-79.

Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Russell, B., & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol. *School Science and Mathematics*, *102*(6), 245-253.

Results Organized into Four Themes

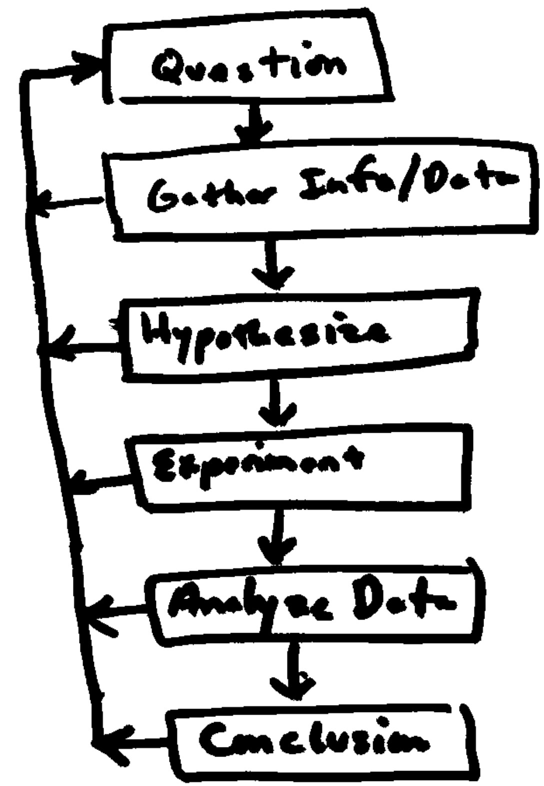
- Beliefs about inquiry
- Instructional change
- Student outcomes
- Building the bridge

Beliefs about Scientific Inquiry – BSI Metric

- Teachers asked to draw and explain their models of science inquiry and respond to several existing models before and after RET
- Scoring system based on expert views of inquiry from Harwood's Activity Model (2004) & faculty interviews
- Interviews coded and scored by frequency of codes **(BSI metric)**

Code	Description	Rating	Score
Looping	Continual process w/ multiple iterations, new questions emerge; refine question	High	2
Communi-cation	Discuss/share ideas; publish, present findings	Med	1
Carry out Study	Do experiment, make observations, collect data	Sci Method	0
Direction	Step-by-step process, order important	Low	- 1

Harwood, W.S. (2004). A new model for scientific inquiry: Is the scientific method dead? *Journal of College Science Teaching, 33*(7), 29-33.



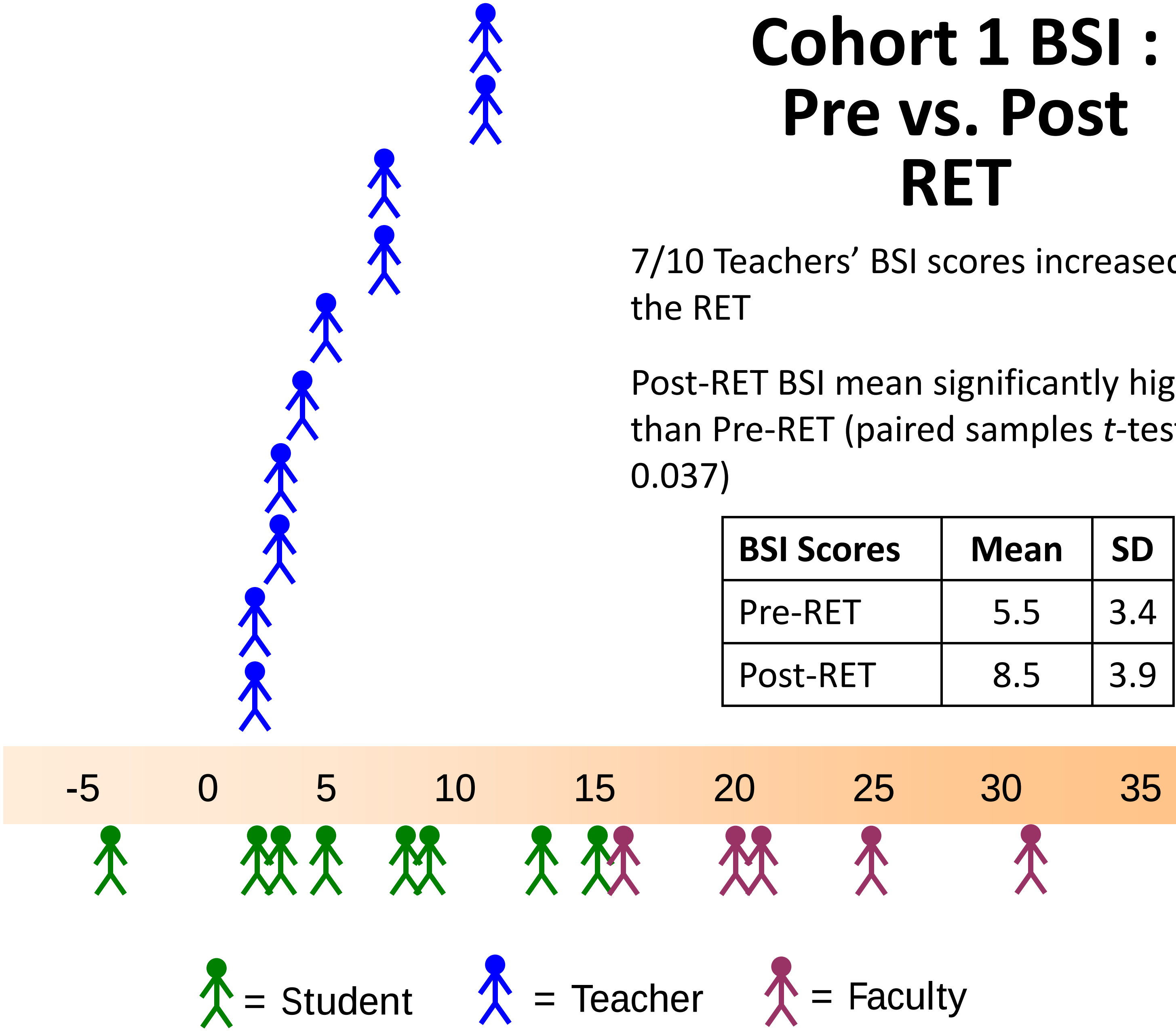
Teacher Model, Summer 2006

Cohort 1 BSI : Pre vs. Post RET

7/10 Teachers' BSI scores increased after the RET

Post-RET BSI mean significantly higher than Pre-RET (paired samples *t*-test, $p = 0.037$)

BSI Scores	Mean	SD
Pre-RET	5.5	3.4
Post-RET	8.5	3.9



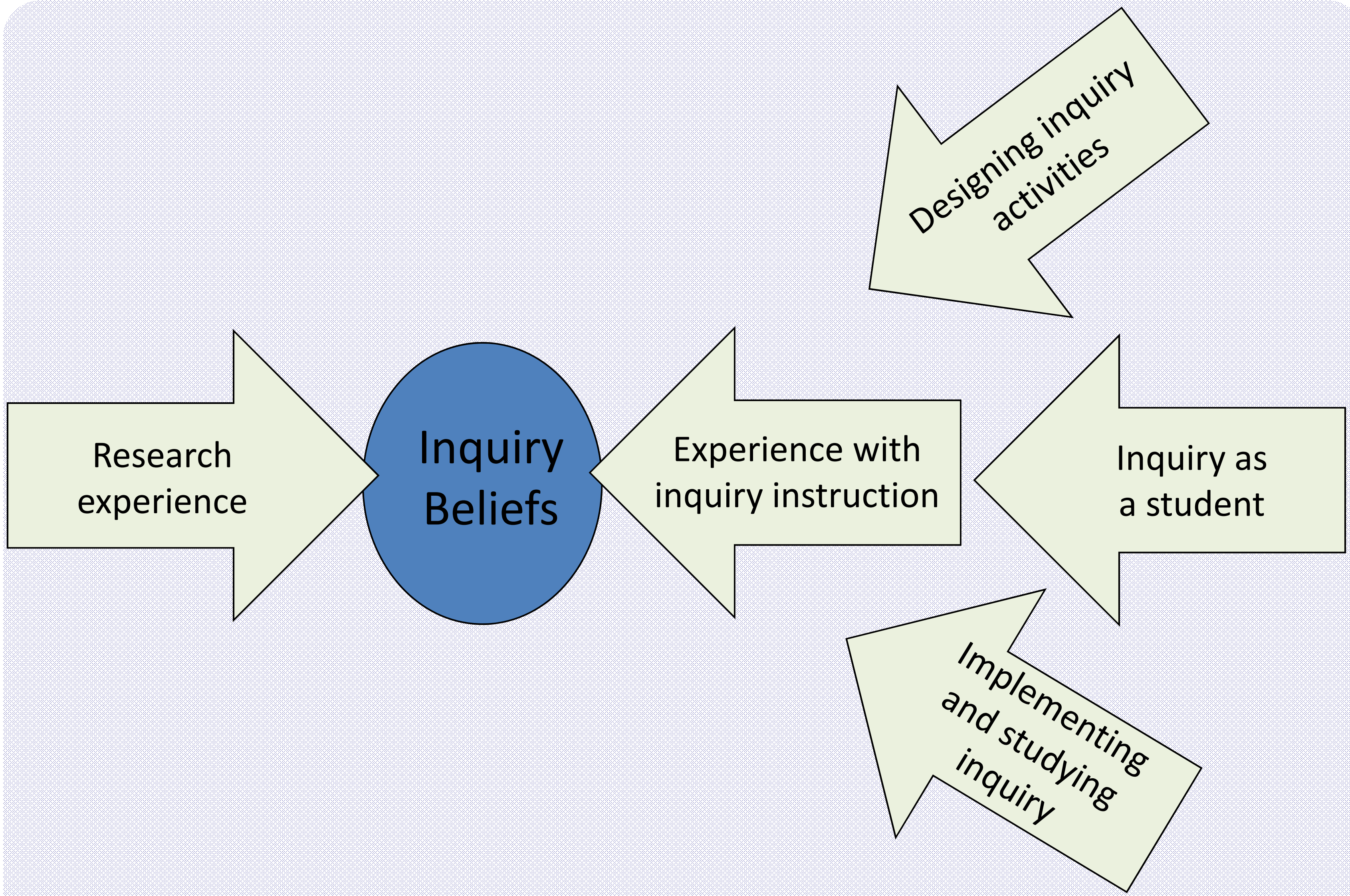
Kennedy, L. M., Yezierski, E. J., Herrington, D. G. (2008). Whose science is it anyway? Models of science according to chemistry students, faculty, and teachers. *Science Educator, 17*(*1*), 1-9.

Beliefs About Inquiry

In post program interviews, **8 of 9 teachers** indicated that their **understanding of inquiry had changed**.

- **I'm not really even sure that I understood what inquiry meant beforehand** and now, whatever it is that I thought it did before really wasn't (Teacher A, post CD).
- I think **it has a lot to do with understanding inquiry differently** and that you really do need to research what is known before you progress (Teacher D, post CD).
- **A better understanding of what inquiry instruction is and the implementation of that and seeing it firsthand**, what it's all about. I think my mindset has changed. Obviously it has changed! (Teacher K, post CD)

Factors Impacting Beliefs about Inquiry



Factors Impacting Beliefs about Inquiry Research Experience (7 of 9)

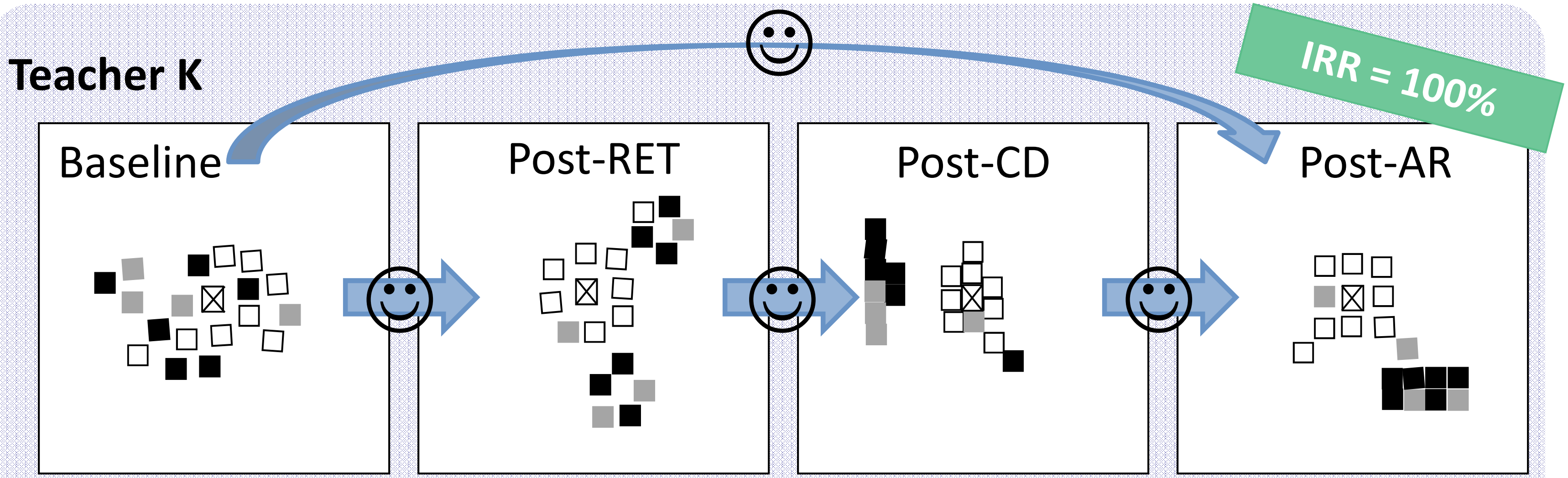
- I guess maybe in the **past I thought that researching known things was just contrary to good inquiry**, but I now see that there is value in understanding what is already known … **from a scientific standpoint I don't think anybody would argue with finding out what's already known so that you can stand on their shoulders and go further…** (Teacher V, post CD)
- …**well if my goal is for my students to actually be scientists here are some things that scientists do…I know that because I am one and I've been doing some science**… (Teacher S, post CD)

Factors Impacting Beliefs about Inquiry Experience with Inquiry Instruction (5 of 9)

- I remember making comments about this in class that **inquiry has to be lab activities and it's not just about doing conceptual learning … both activities that I wrote for this class and many of the things that I've done in my classroom to modify are more about conceptual learning, and not about lab-based learning**. (Teacher A, post CD)
- Q: What would you attribute these changes to?

  A: I think a lot of it **is…is that because I have been doing this as a student this whole time**… being taught by [X]. Sitting under what I think is an inquiry model (Teacher S, post CD)

Beliefs vs. Classroom Practices



- *Ones that I based here are very similar to that in year 1, however, there were so many things connected; it's not a distinct separation between different cards that I have on there… Second year, a little more defined differences in the cards… And then I went from there to two distinct groups, a couple outliers. Well, it's still a little webby, you know?* ***But I find it interesting going from a webby kind-of scattered [model], and as I was able to go through the program, I really had a better understanding and connection of inquiry-based instruction*** (Teacher 1, post-AR interview).

Classroom Practices: RTOP
Reformed Teaching Observation Protocol

- Measures class alignment with science and math reforms

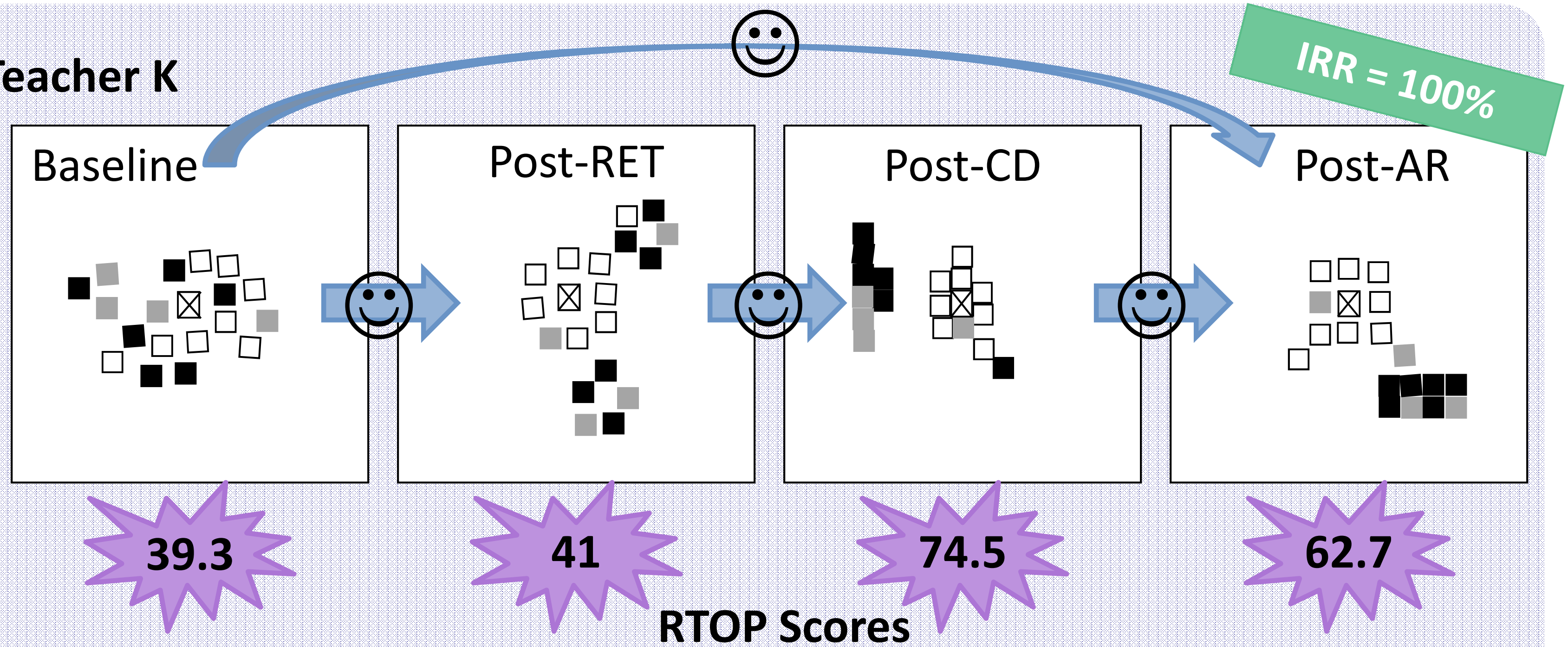
RTOP items ⟷ content and pedagogy standards in *NSES* and the *Benchmarks*

- 25 items each evaluated on a 5-point scale (0-4, 100 pt. max)
- Three subscales
  - Lesson design and implementation (**Design**) – 5 items
  - Content and process knowledge (**Content**) – 10 items
  - Classroom culture (**Culture**) – 10 items
- Validity and Reliability of RTOP (Sawada, et al., 2002)
  - Training
  - 3 raters

Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Russell, B., & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol. *School Science and Mathematics*, *102*(6), 245-253.

Beliefs vs. Classroom Practices

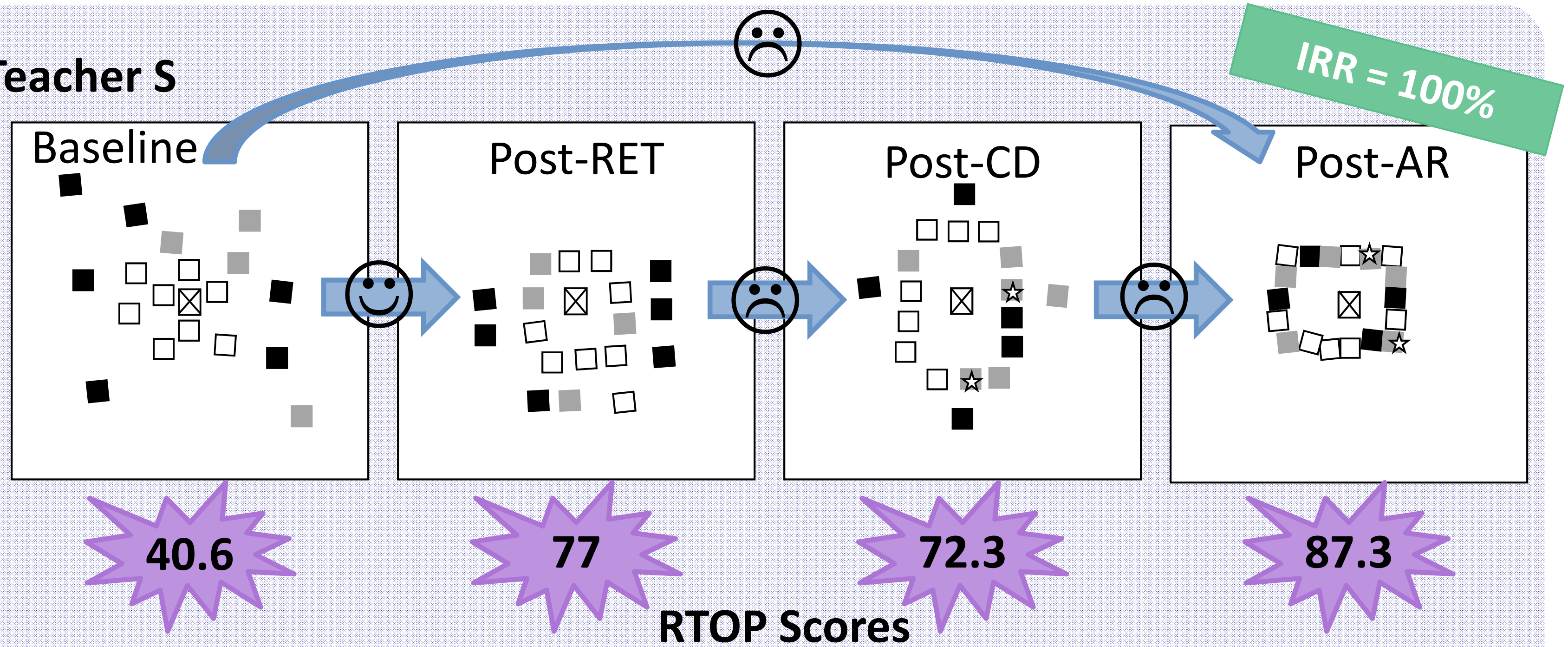
Teacher K



- *Ones that I based here are very similar to that in year 1, however, there were so many things connected; it's not a distinct separation between different cards that I have on there… Second year, a little more defined differences in the cards… And then I went from there to two distinct groups, a couple outliers. Well, it's still a little webby, you know?* ***But I find it interesting going from a webby kind-of scattered [model], and as I was able to go through the program, I really had a better understanding and connection of inquiry-based instruction*** (Teacher 1, post-AR interview).

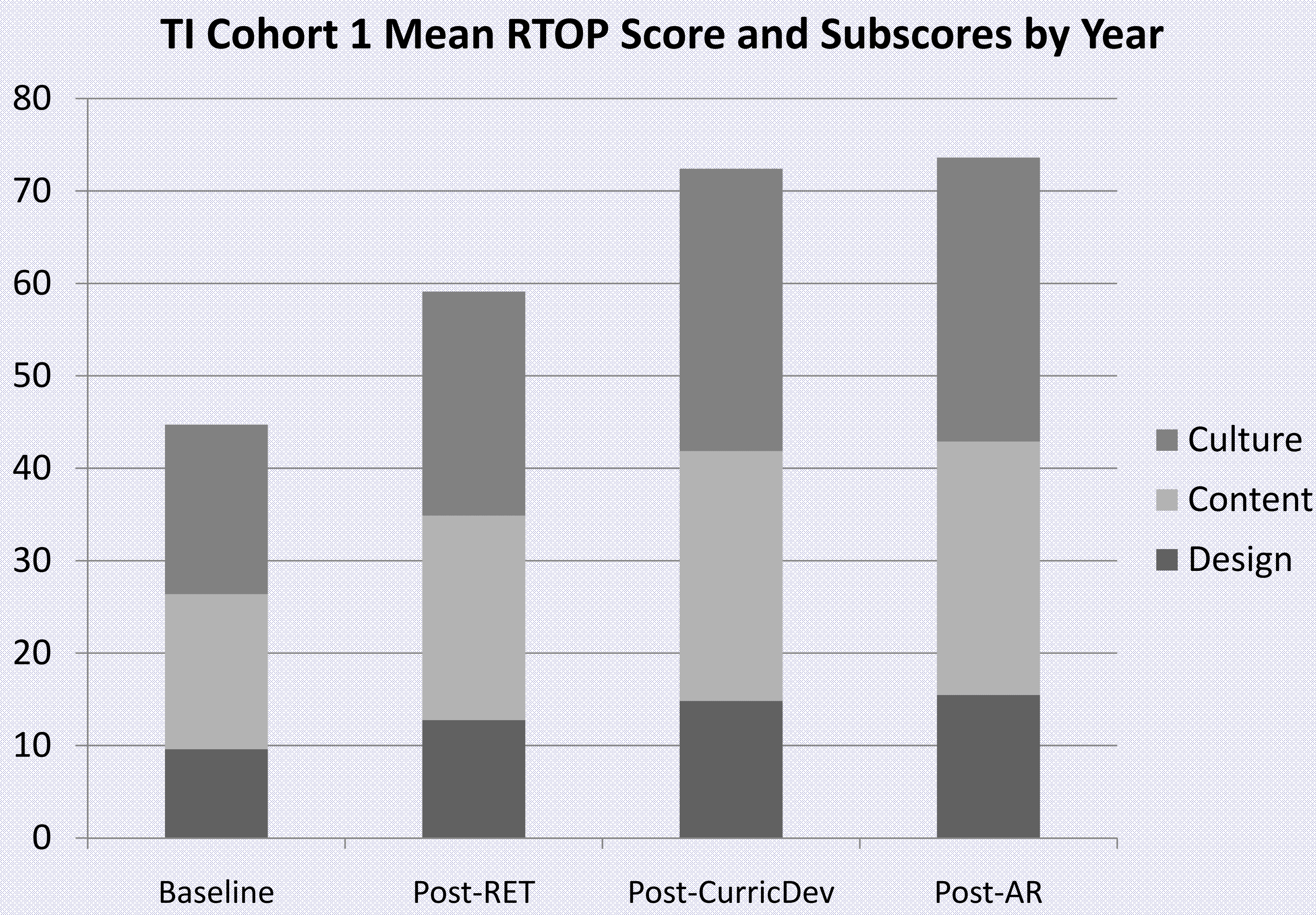
Beliefs vs. Classroom Practices

Teacher S

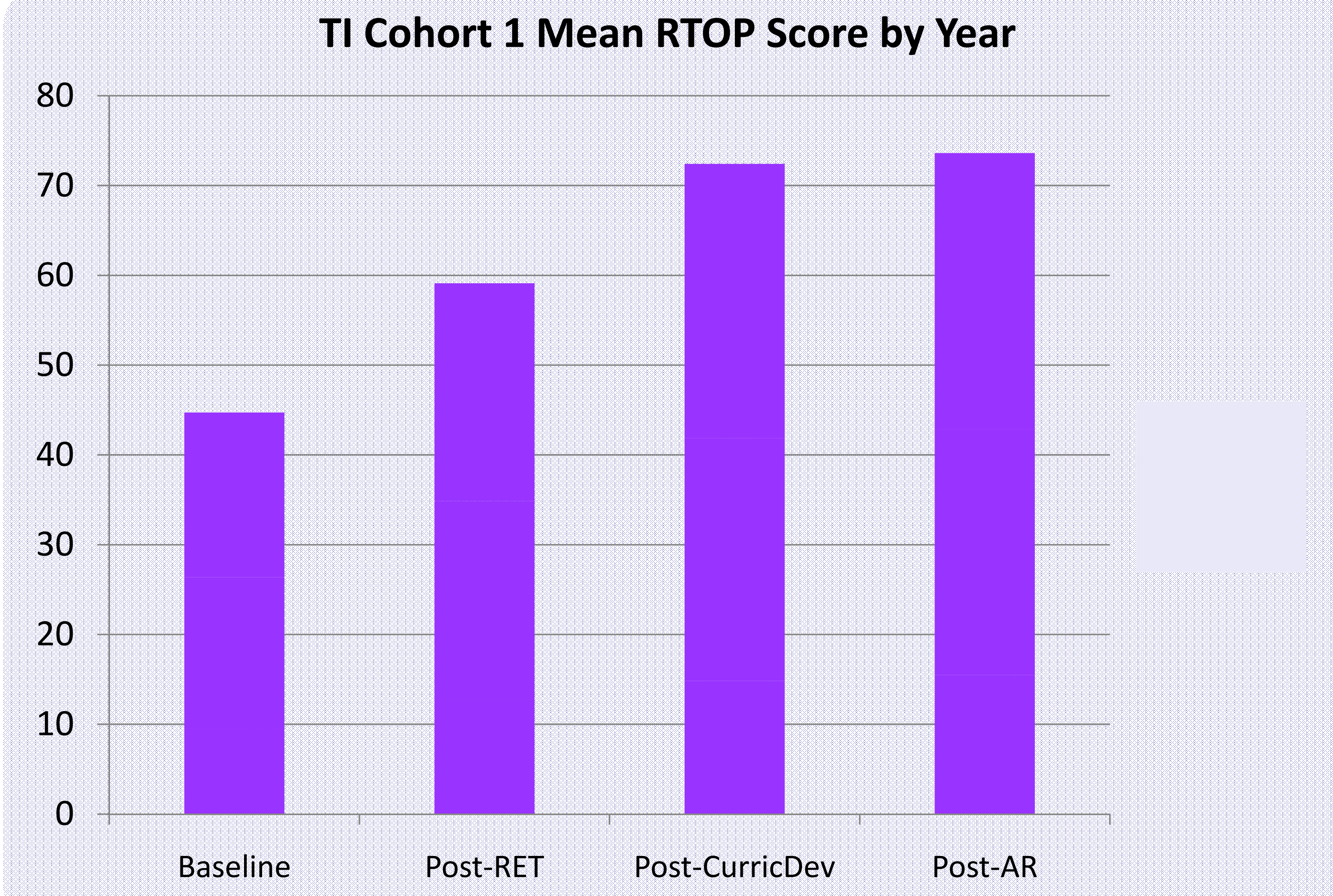


- Interviewer: *So, I'm seeing that they are all the same distance away.* Teacher 6: *Yup, pretty much.* ***I think really these are all things that I do and I think that depending on how you use them they can all be inquiry-based…*** Interviewer: *So you said that you put them all equal distance because you use them all in your classroom, and* ***so that to me suggests that you view your classroom as an inquiry classroom?*** Teacher 6: ***Yes I do****, although I don't want to be arrogant and say that it's perfect 'cause it's not* (post-AR interview).

Instruction: Results for Cohort 1 (*N* = 6)



RTOP Total $p = 0.001, \eta^2 = 0.80$



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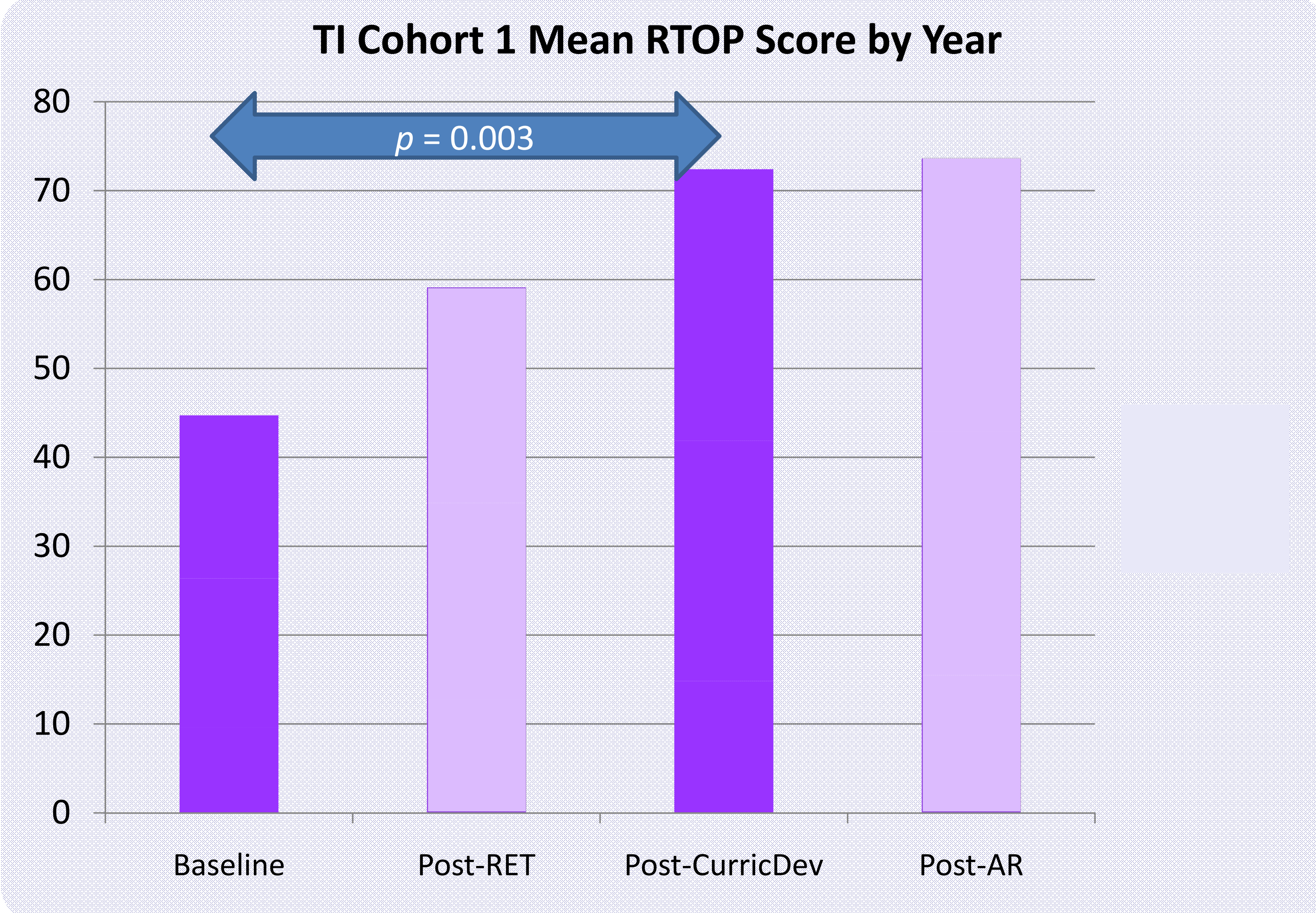
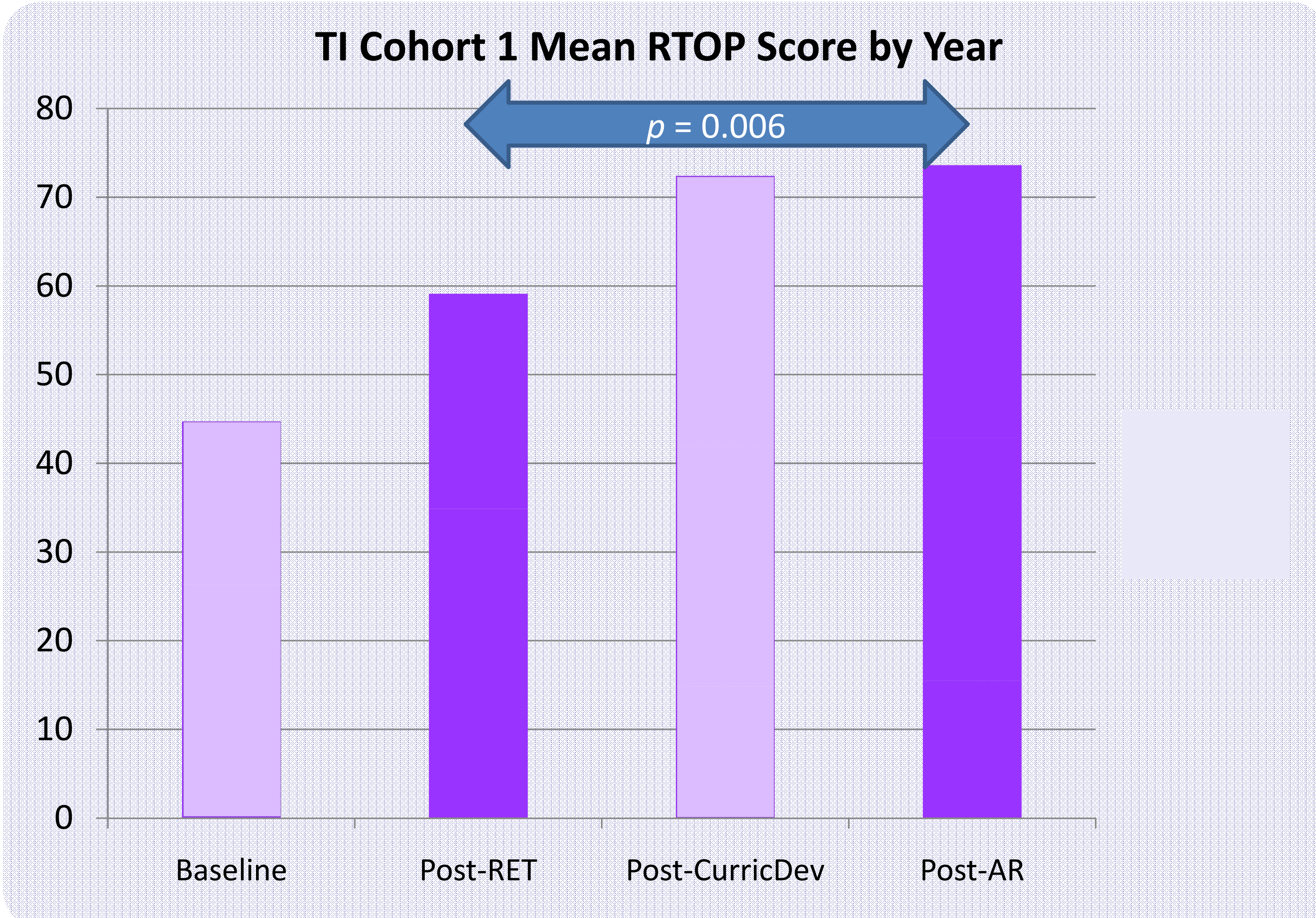
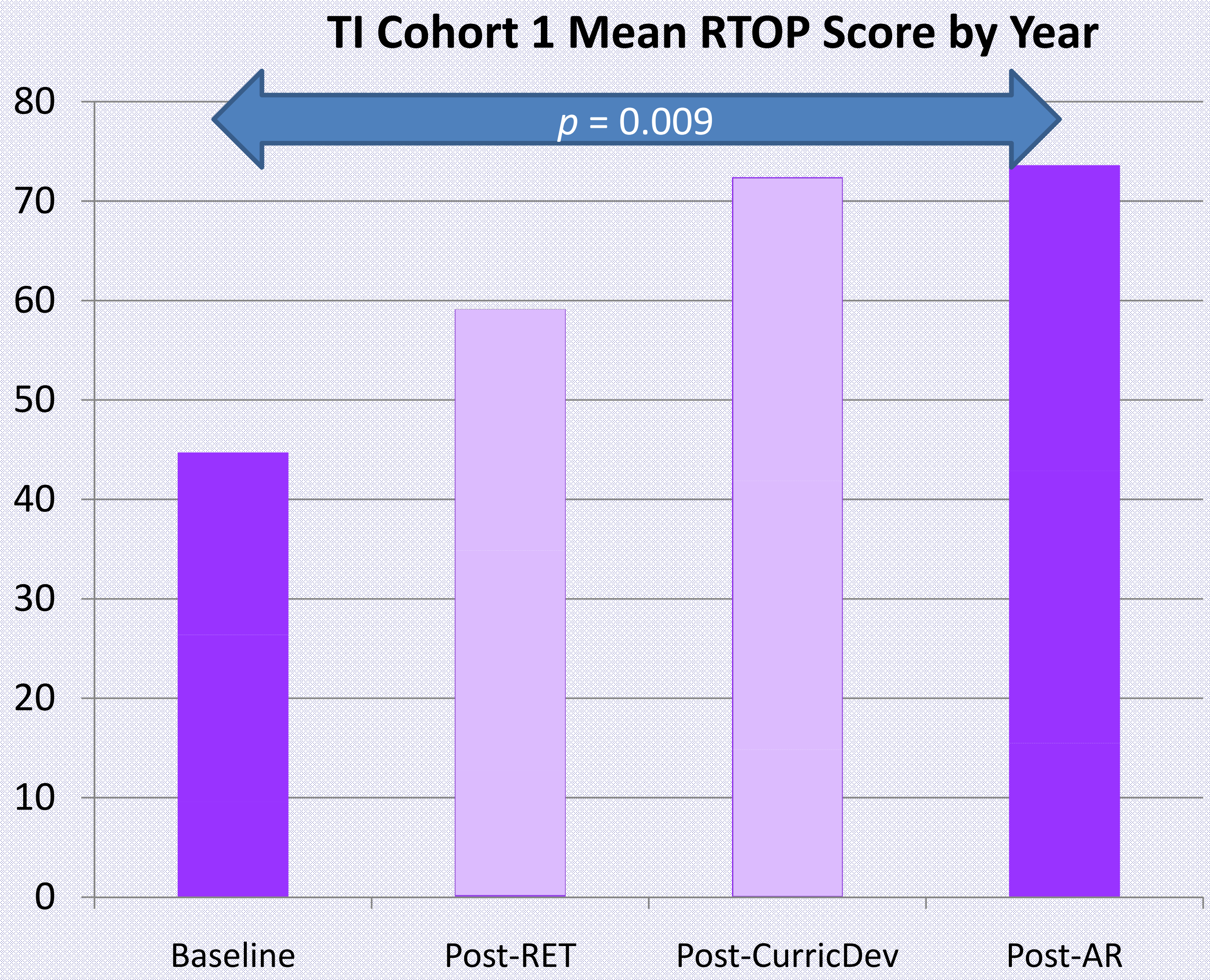


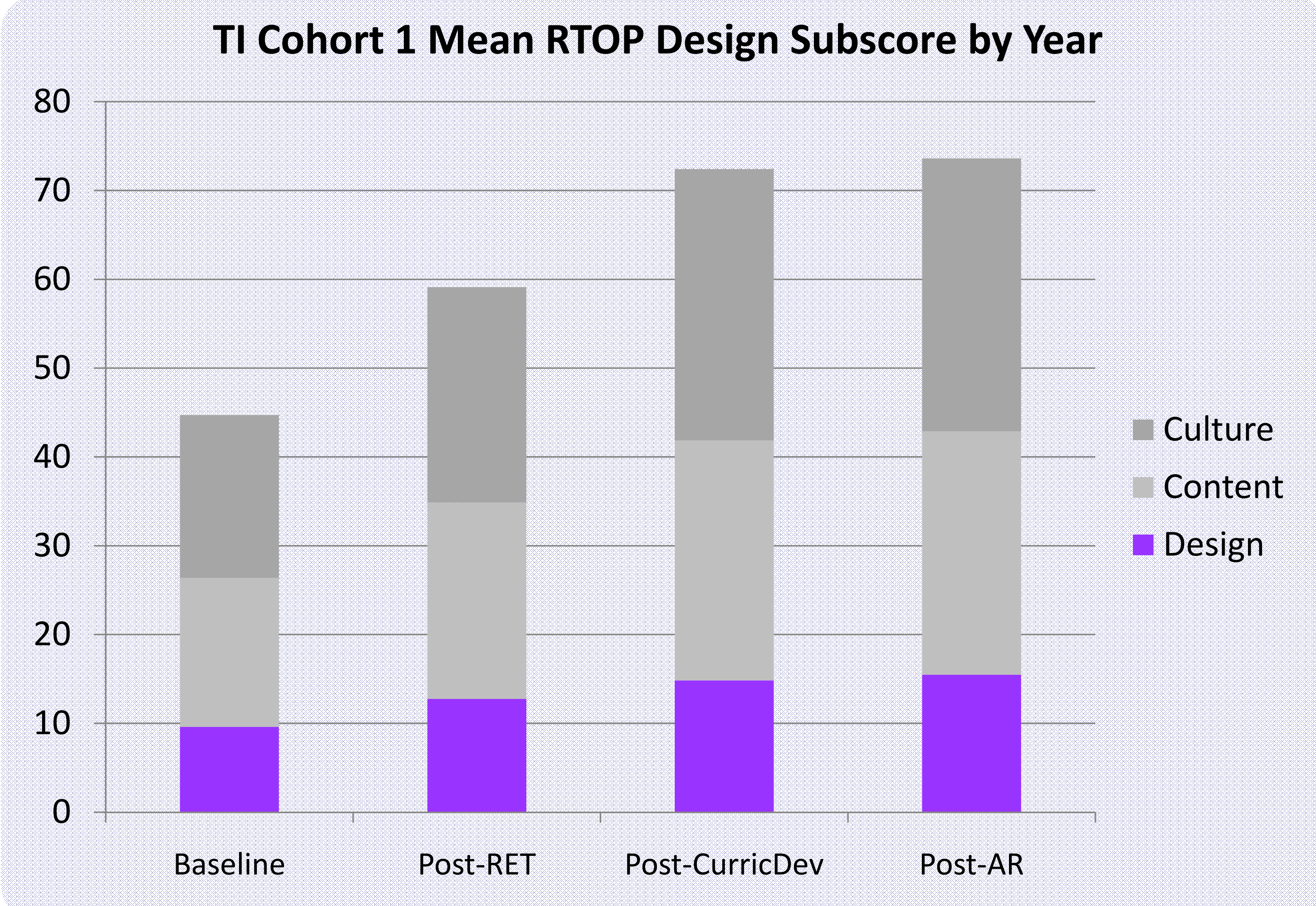
RTOP Total $p = 0.001, \eta^2 = 0.80$



RTOP Total $p = 0.001, \eta^2 = 0.80$



Design Subscale $p = 0.003, \eta^2 = 0.68$



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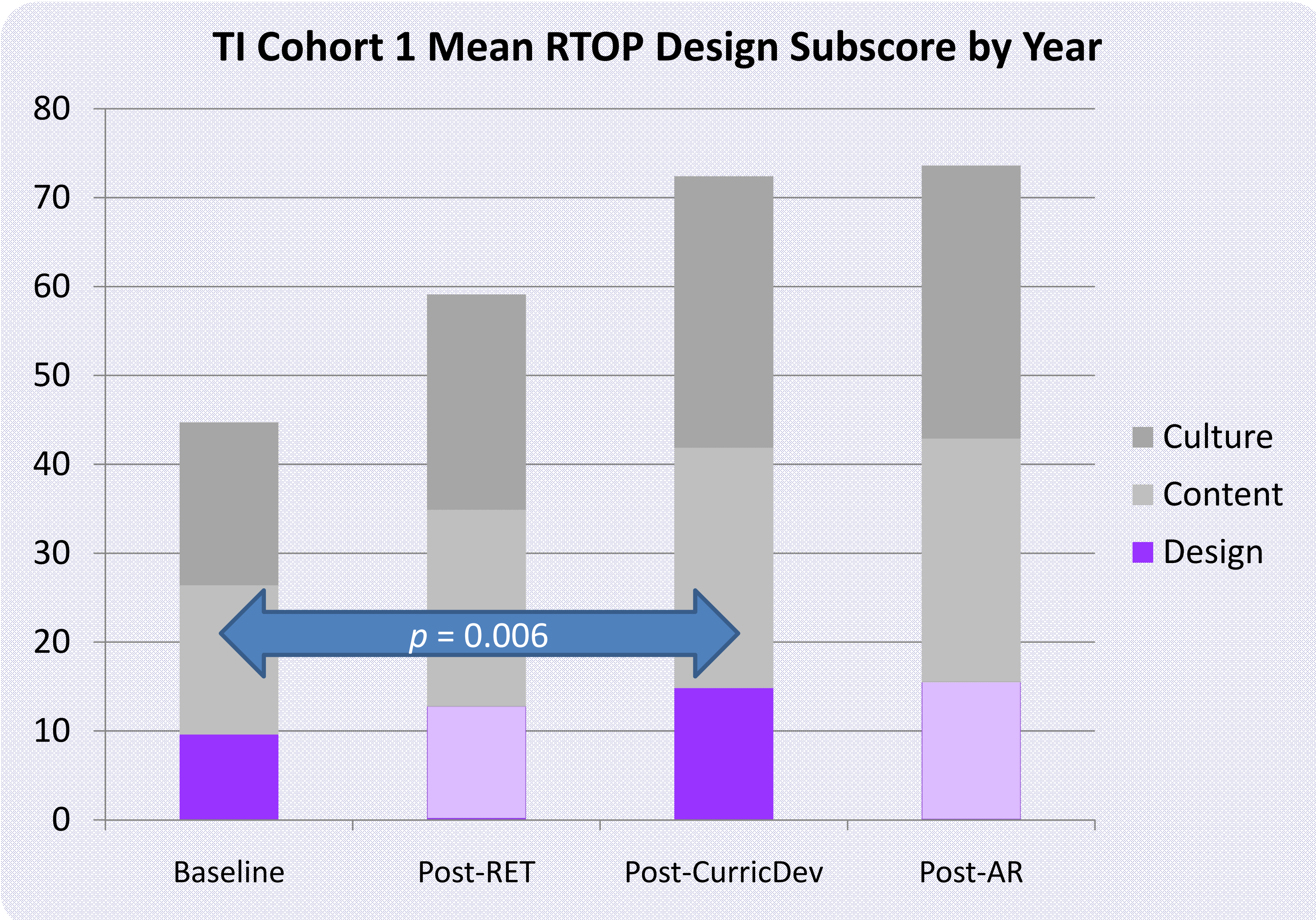

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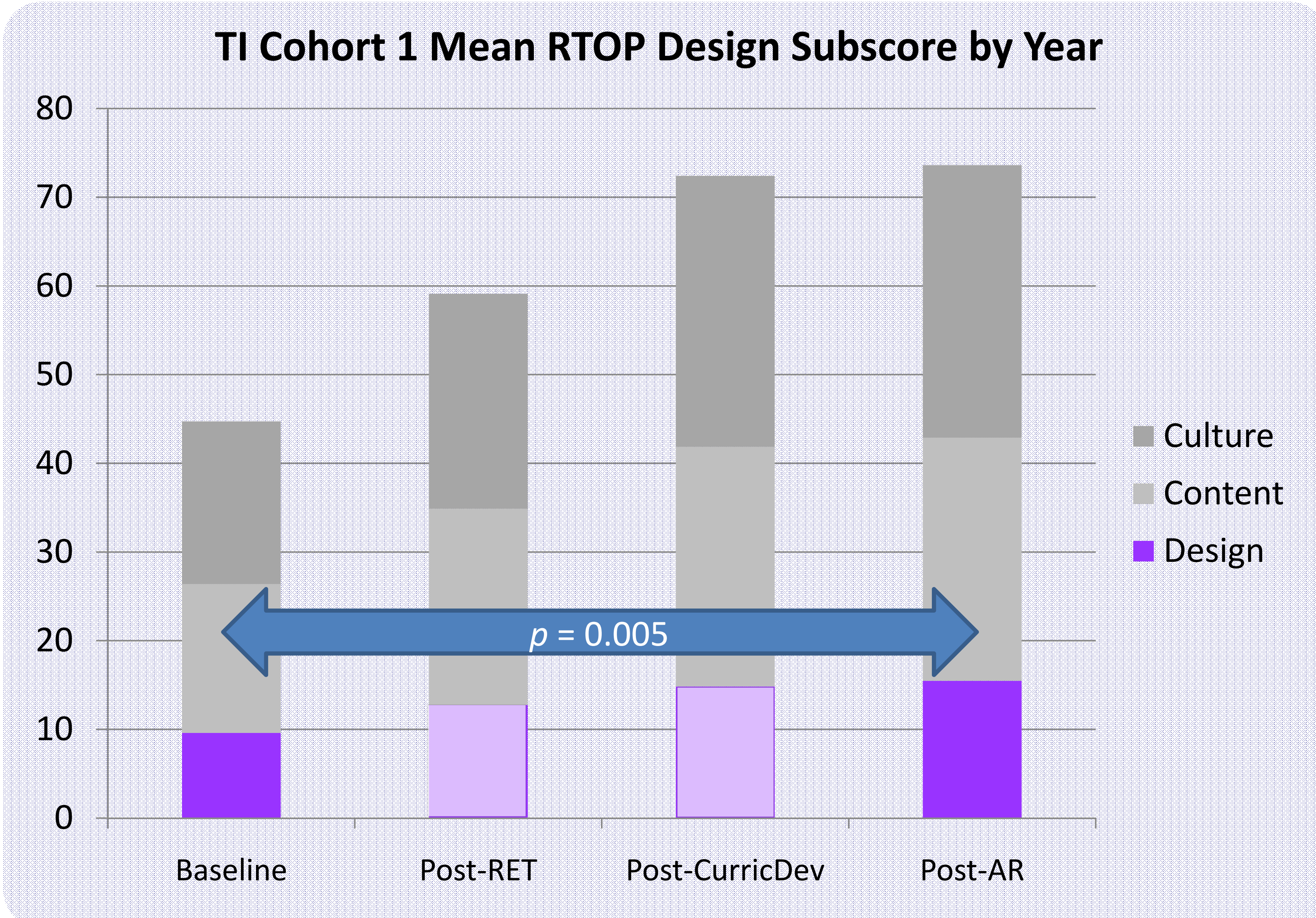
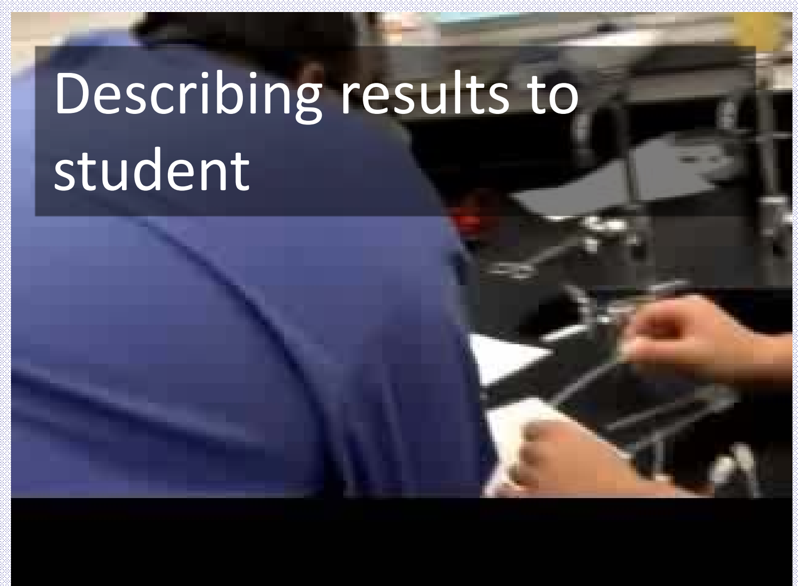


Observing Changes in Practice (Design): Baseline Yr - Convergent Set-Up w/ Verification

Lesson Introduction: Precipitation reactions - Applying solubility rules to describe reactions with balanced chemical equations

Yea…it's mercury, but we

Modeling how to write balanced equations from results and using solubility rules



Design Post-RET: Baby Steps Toward Inquiry

Gave students scrambled procedure to determine the heat of fusion of H_2O; after a few minutes stops them because they do not quickly converge on a strategy

Let's stop for a second and let's find

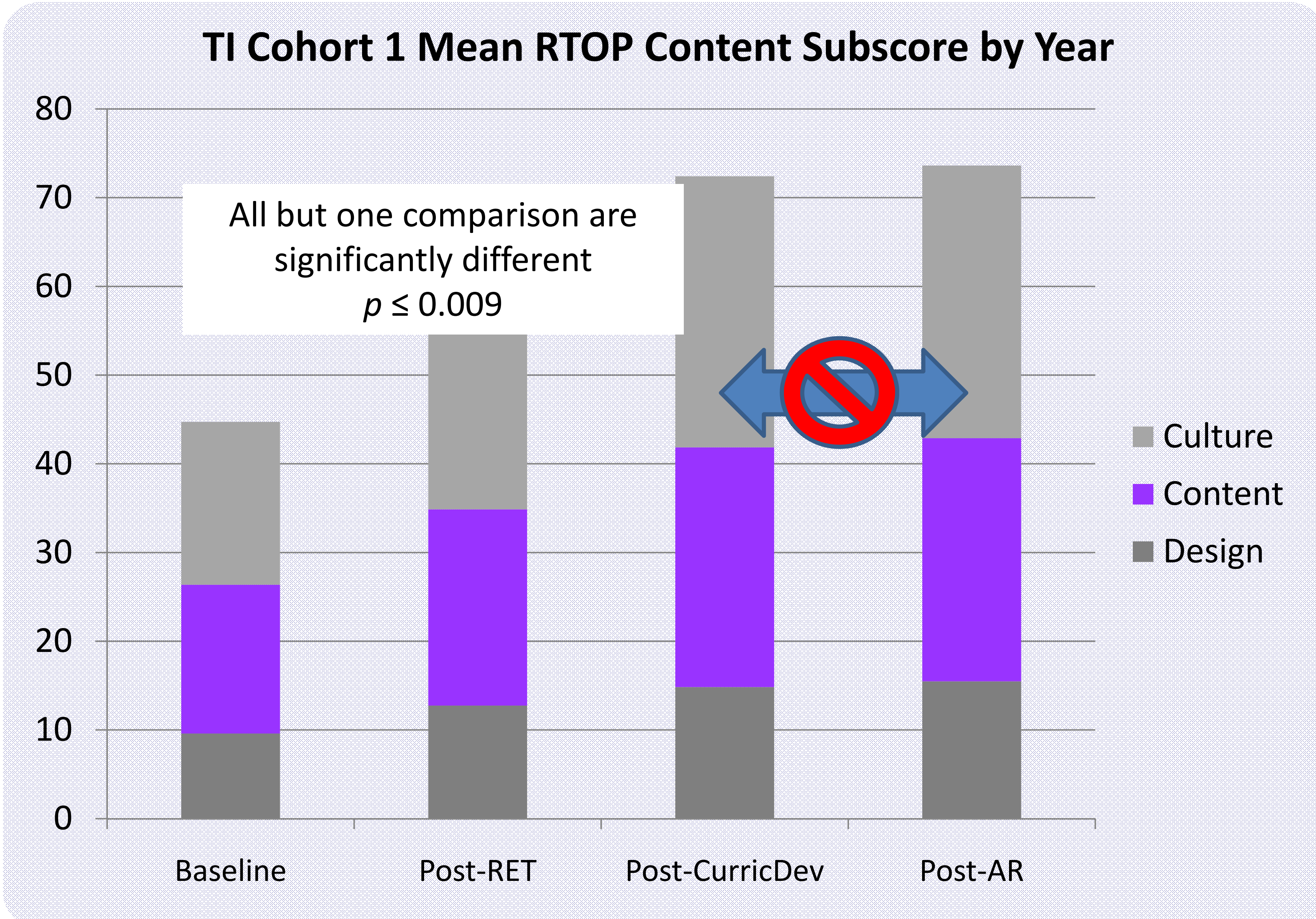
Responds to student question with a divergent response; students create data tables

Design Post-CD: Divergent Set-Up with Student-Developed Procedures

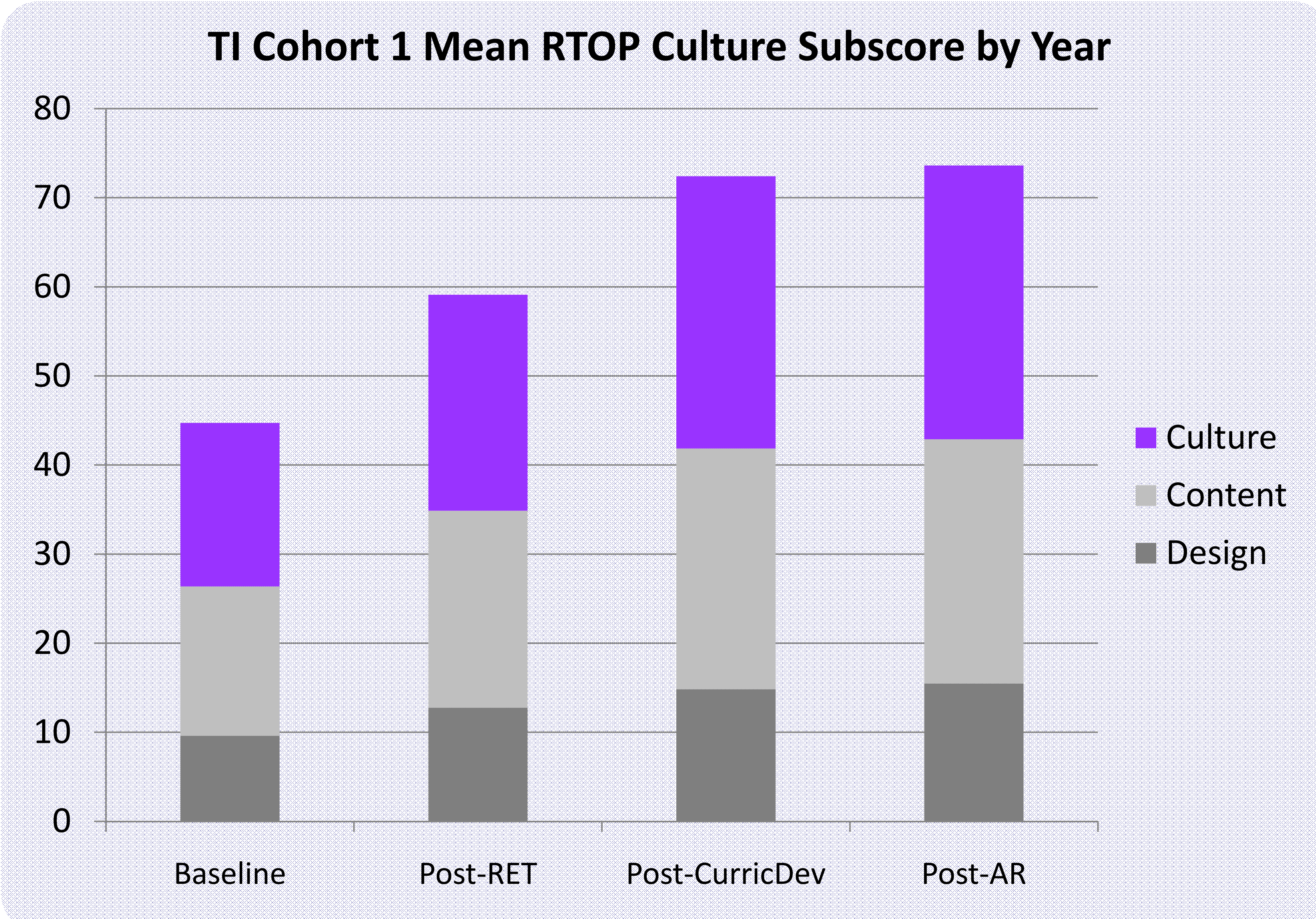
Provides problem-based scenario to determine the density of a solution and challenges students to design procedure

Encourages students to devise and document procedures in a way commensurate with practicing scientists

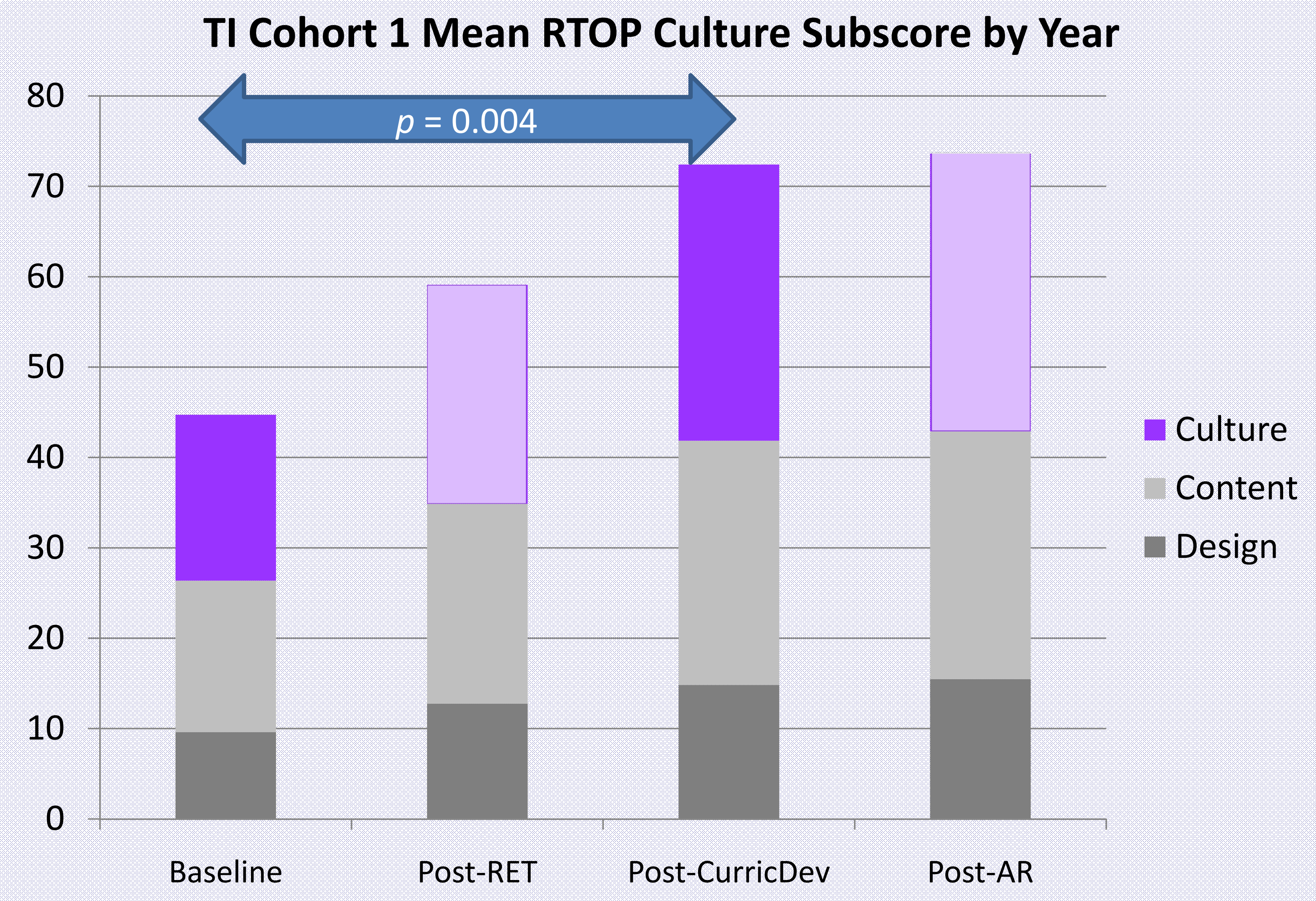
Content Subscale $p = 0.001, \eta^2 = 0.84$



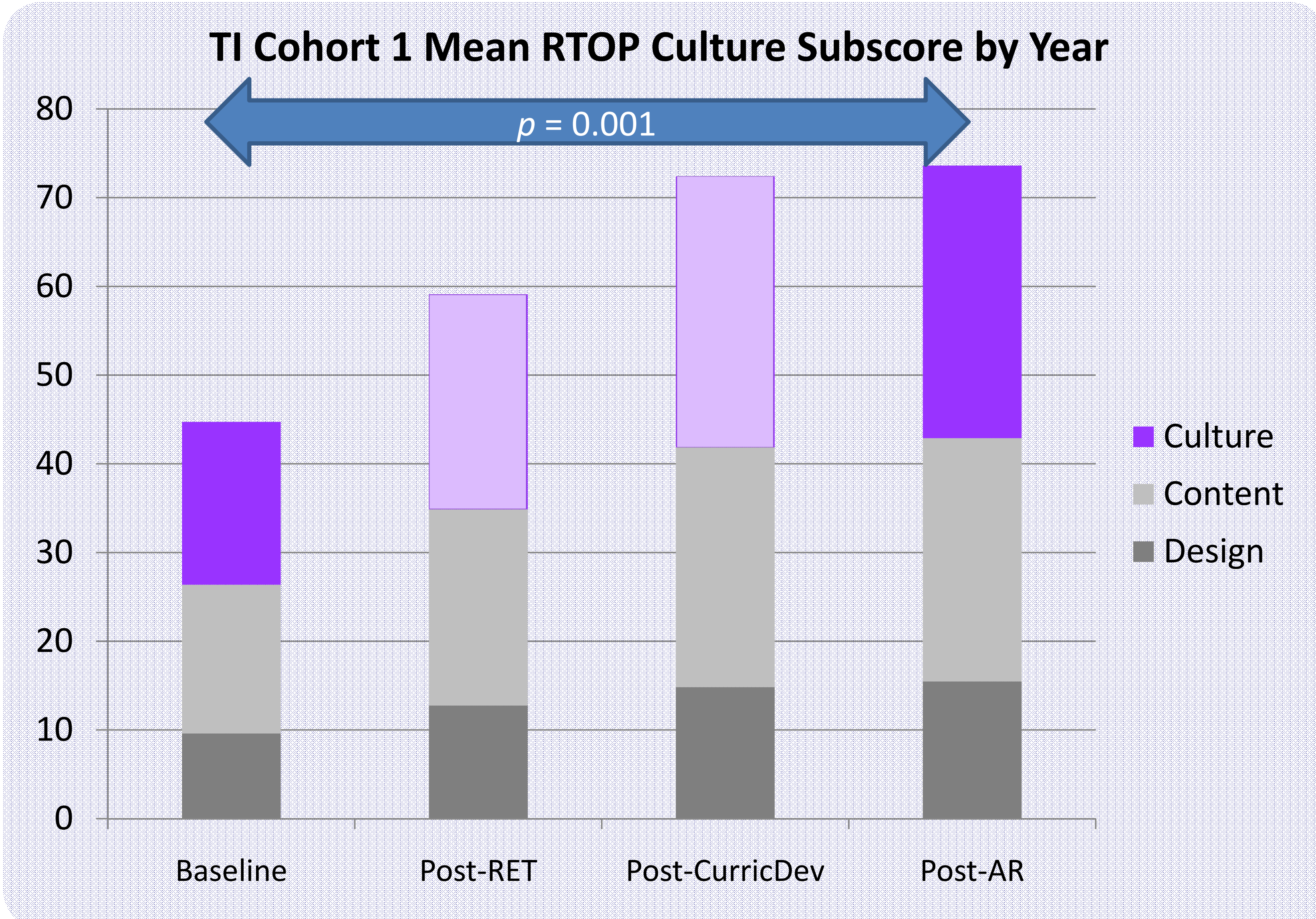
Culture Subscale $p = 0.002, \eta^2 = 0.72$



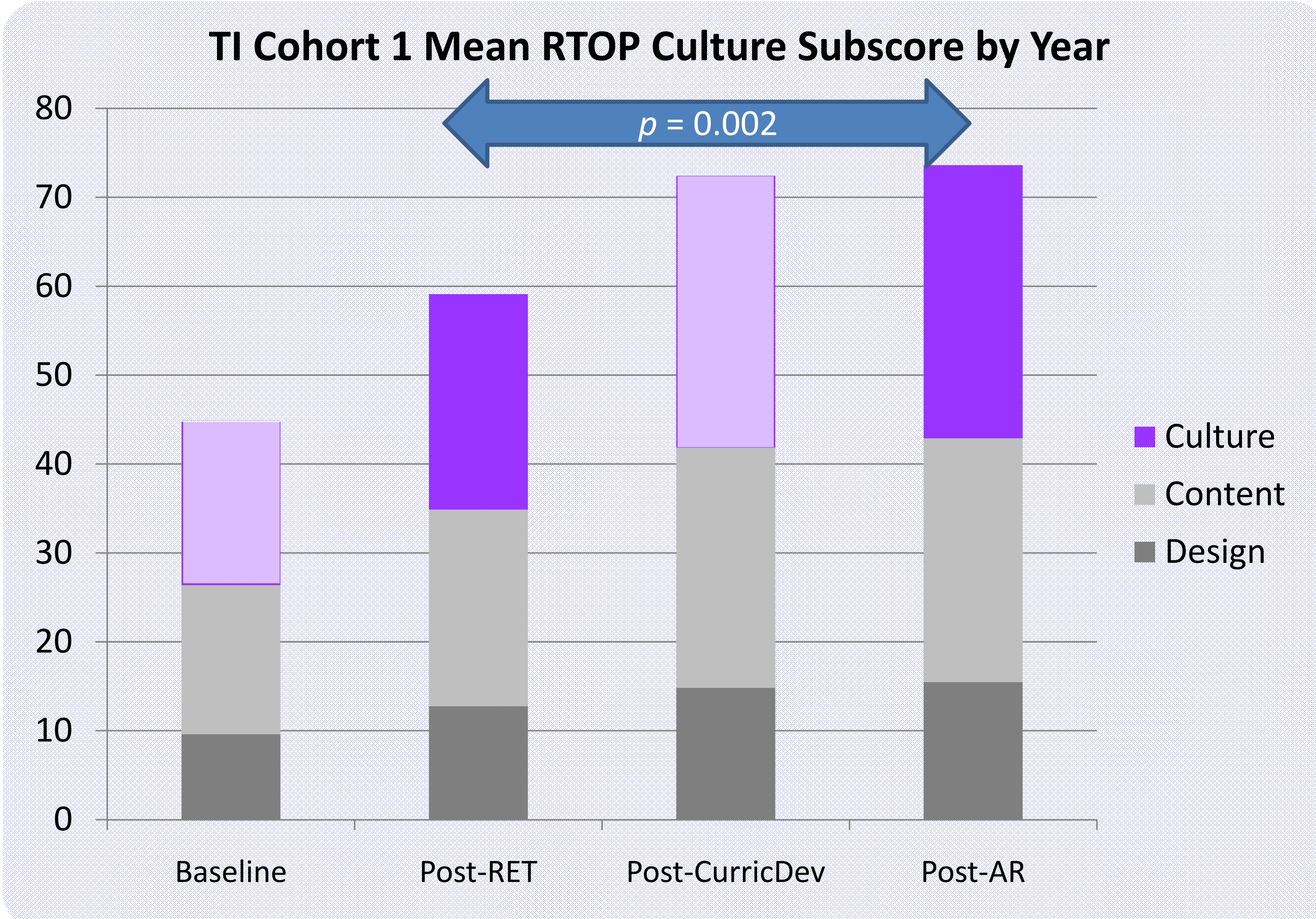
Culture Subscale $p = 0.002$, $\eta^2 = 0.72$



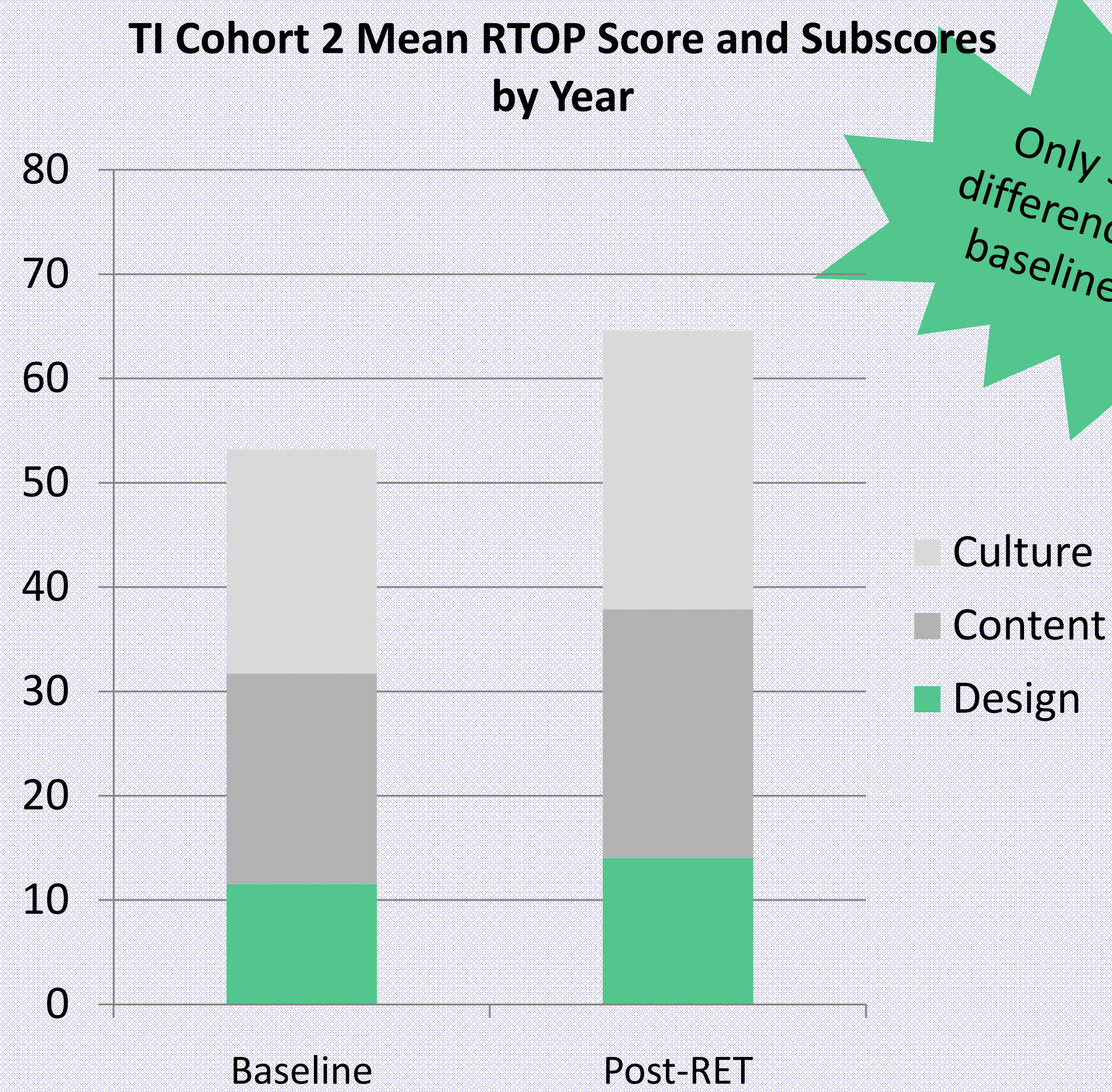
Culture Subscale $p = 0.002, \eta^2 = 0.72$



Culture Subscale $p = 0.002, \eta^2 = 0.72$



Design Subscale $p = 0.041, \eta^2 = 0.47$



Only significant difference between baseline and RET

Classroom Instruction – RTOP (Sawada, et al., 2002)

LESSON DESIGN & IMPLEMENTATION

	Never Occurred				Very Descriptive
1. The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	**0**	**1**	**2**	**3**	**4**

3. In this l
present

4. Th
alt
so

For every lab … I made a point to tie it back to the content that we were covering and usually that came in the form of pre-lab quest… kids had to answer…. (Teacher A, post CD)

Well, every time I look at a unit now, I try to say, "How can I get these kids to construct their own knowledge?" … You can do other techni…
do som…
I look a…

…one they just had to make their own buffer and see if it worked, and those were their instructions…well I did give them a set of chemicals to chose from (Teacher S, post CD)

Classroom Instruction – RTOP (Sawada, et al., 2002)

CONTENT and PROCESS KNOWLEDGE

	Never Occurred				Very Descriptive
7. The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4

I would say that that [the intermolecular forces lab] was more of a modification of a current lab … and that one went well. **Whether it's a result of me doing a better job tying those** … **together, or if it's**

I do a lot more modeling than I've done in the past. Particulate level models through [the kinetic molecula…**lab], through**

The students are now trained in such a way that when they return from the lab to their desks to do their analysis they do not just search for "the right answer." … **When the students are seeking to answer any questions they are willing to discuss and argue about an answer until they come to understand all the sides and decide what chemistry is really happening.** It's fun! (Teacher S, implementation journal)

Classroom Instruction – RTOP (Sawada, et al., 2002)

CULTURE

Never Occurred — Very Descriptive

17. The teacher's questions triggered divergent modes of thinking. 0 1 2 3 4

23. In general

24.

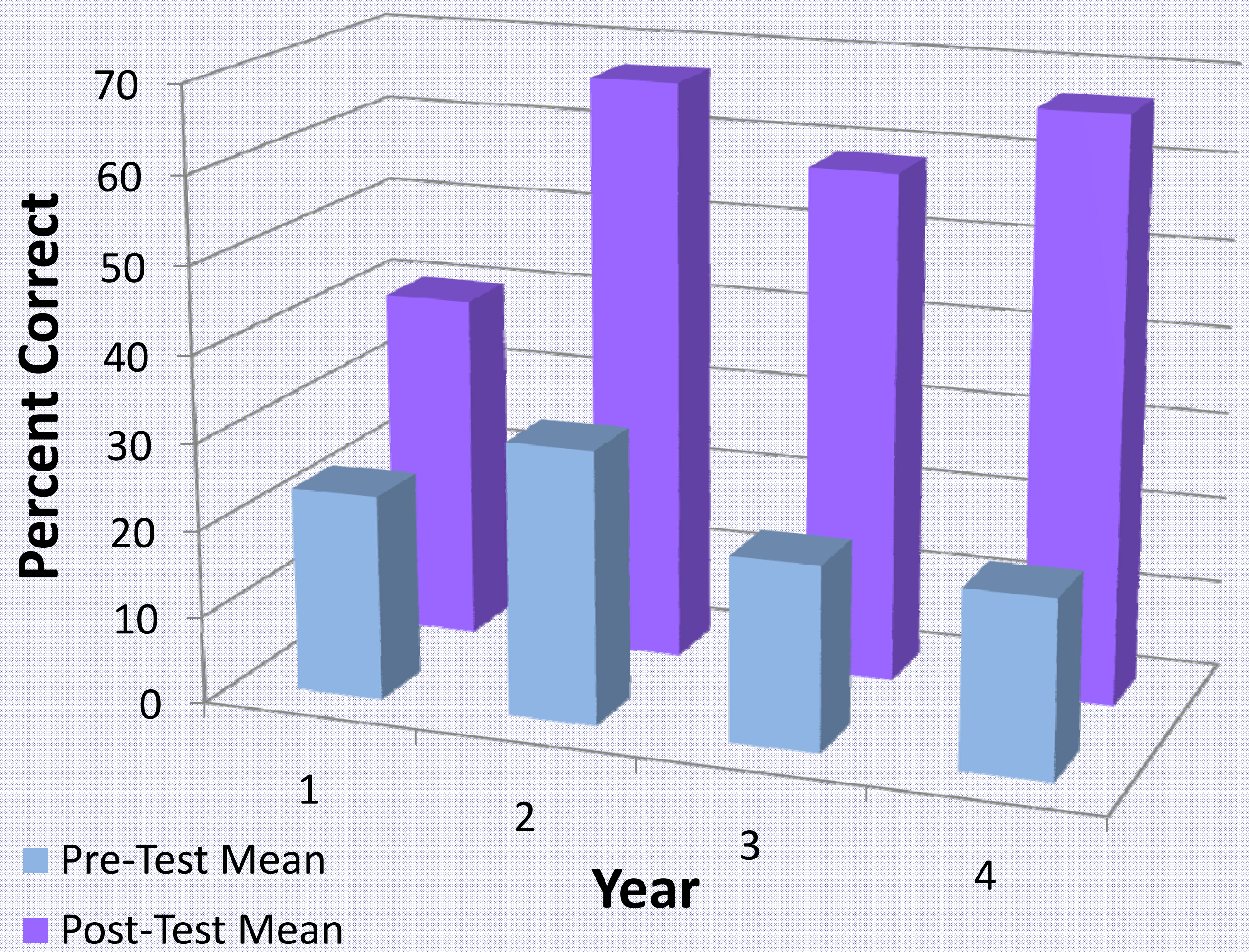
I just gave them solution one and solution two, and I gave them a bunch of tools, of which one was a ruler, [to determine the ratio for making t… …imum amount of

You know… **like the first day, I just let them go. I answered a few questions, I let them go, I let them strug… …a little bit. The second day, I**

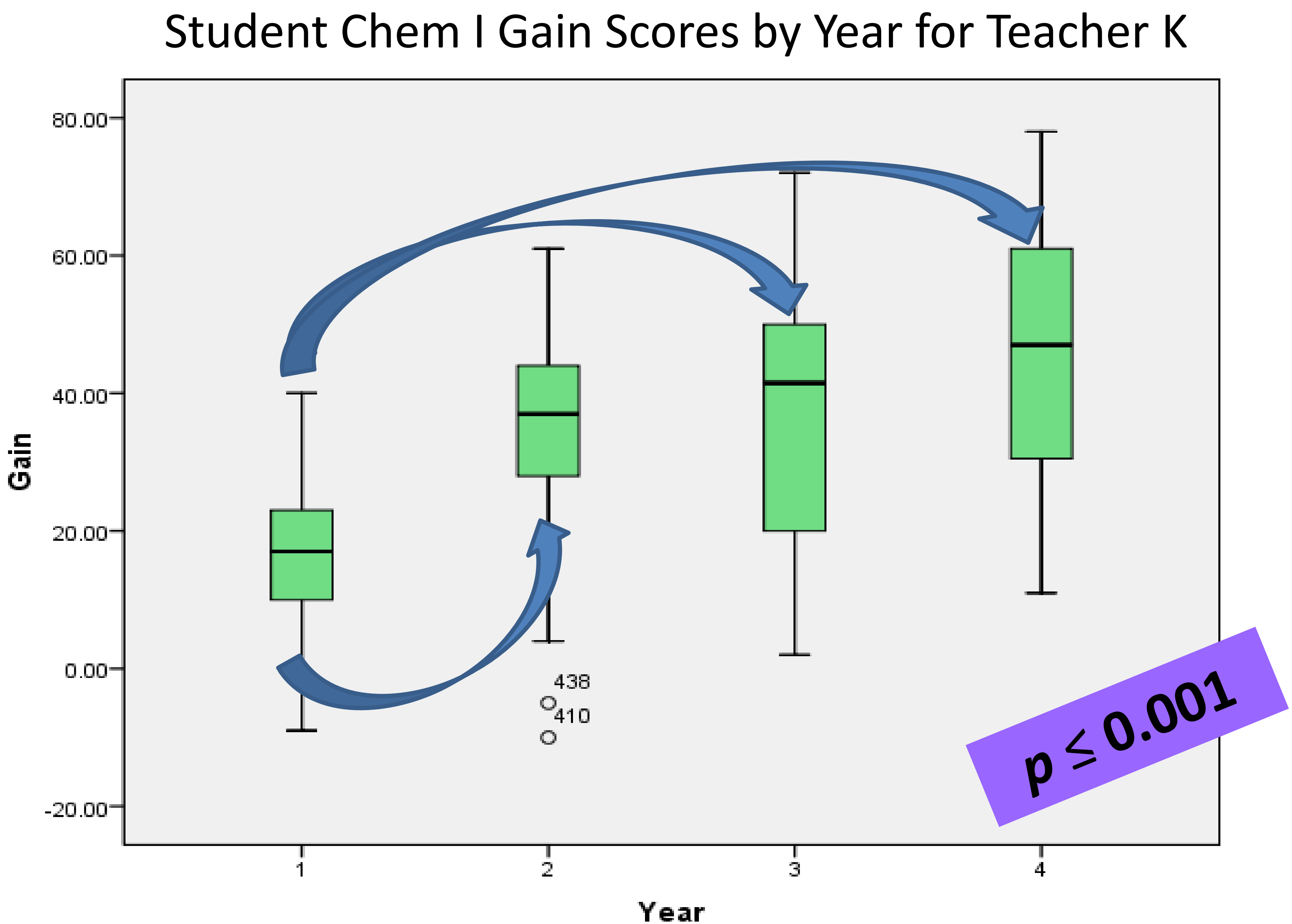
Back to this culture of inquiry, it's spilling out all over. I'm applying these ideas in my math classes too and it's fun to force the students to look to resources other than me to find information. I know it's difficult for them at first since they are so used to teachers giving them answers… (Teacher S, implementation journal)

Student Outcomes:
Instruments from ACS Examinations Institute

Mean Pre- and Post-Test Chem I Scores by Yr for Tchr K



Data Sets Warranted Nonparametric Analyses



Significant Differences Between Yearly Student Gain Scores: AP Chemistry

ONE YR Change

Tcr	Yr 1-2	Yr 2-3	Yr 3-4
5		*p* = 0.007	*p* ≤ 0.001
10	no data		
6	*p* ≤ 0.001	*p* ≤ 0.001	*p* ≤ 0.001
3			*p* ≤ 0.001

TWO YR Change

Yr 1-3	Yr 2-4
p ≤ 0.001	*p* ≤ 0.001
N/A	
p ≤ 0.001	*p* ≤ 0.001
p = 0.002	

THREE YR Change

Yr 1-4
p ≤ 0.001
N/A
p ≤ 0.001

Increase

Decrease

No Change

Significant Differences Between Yearly Student Gain Scores: Chemistry I

	ONE YR Change			TWO YR Change		THREE YR Change
Tch	Yr 1-2	Yr 2-3	Yr 3-4	Yr 1-3	Yr 2-4	Yr 1-4
2	$p \leq 0.001$		$p = 0.007$	$p \leq 0.001$		$p \leq 0.001$
5	$p \leq 0.001$			$p \leq 0.001$		$p \leq 0.001$
4	no data			N/A		N/A
10	no data			N/A		N/A
9	no data	$p = 0.023$		N/A	$p = 0.008$	N/A
6		$p \leq 0.001$		$p = 0.005$	$p \leq 0.001$	$p \leq 0.001$
7			no data	$p \leq 0.001$	N/A	N/A
1	$p \leq 0.001$		$p \leq 0.001$	$p \leq 0.001$	$p \leq 0.001$	
3		$p \leq 0.001$	$p \leq 0.001$	$p \leq 0.001$		

Teacher Identified Student Outcomes

- Retention/Understanding
- Engagement
- Confidence/Independence
- Frustration and Resolution

Retention/Understanding

- All data is not processed yet **but I feel from conversation in class and looking at the work that students have a much better understanding of density than they have in the past.** (Teacher B, implementation journal)
- I have done lots of inquiry … and I think it is working. I know thinking it is working is not going to get me published anywhere. **But … this was the first time ever in the history of my teaching that NO kids failed the grading period. Coincidence? Maybe, but I don't really believe in coincidences.** (Teacher G, implementation journal)

Engagement

- [Either Ore lab] It took 2 days and 15 minutes of a third day to do and I felt it was worth the time. **Students were engaged, concerned with what was happening and began to see an application from the classroom to lab!** (Teacher K, implementation journal)
- **So once I saw how the kids responded to that type of learning and how much I enjoyed that type of learning that really made me think that this could really work and made a big difference in my classroom.** (Teacher A, post CD)

Confidence/Independence

- **I know this because students told me this and I know this because I could see it … my students' confidence in their understanding of lab improved.** (Teacher A, post CD)
- It has changed my classroom in terms of how my students learn …, **they don't just look to me for direction any more they look for information from other places** (Teacher S, post CD)
- It is weird to have a **group of kids just starting inquiry and having all types of questions and wanting answers that I am refusing to give** when the day before the **students who are in their second trimester just picked up the paperwork and got to work no questions asked…** (Teacher B, implementation journal)

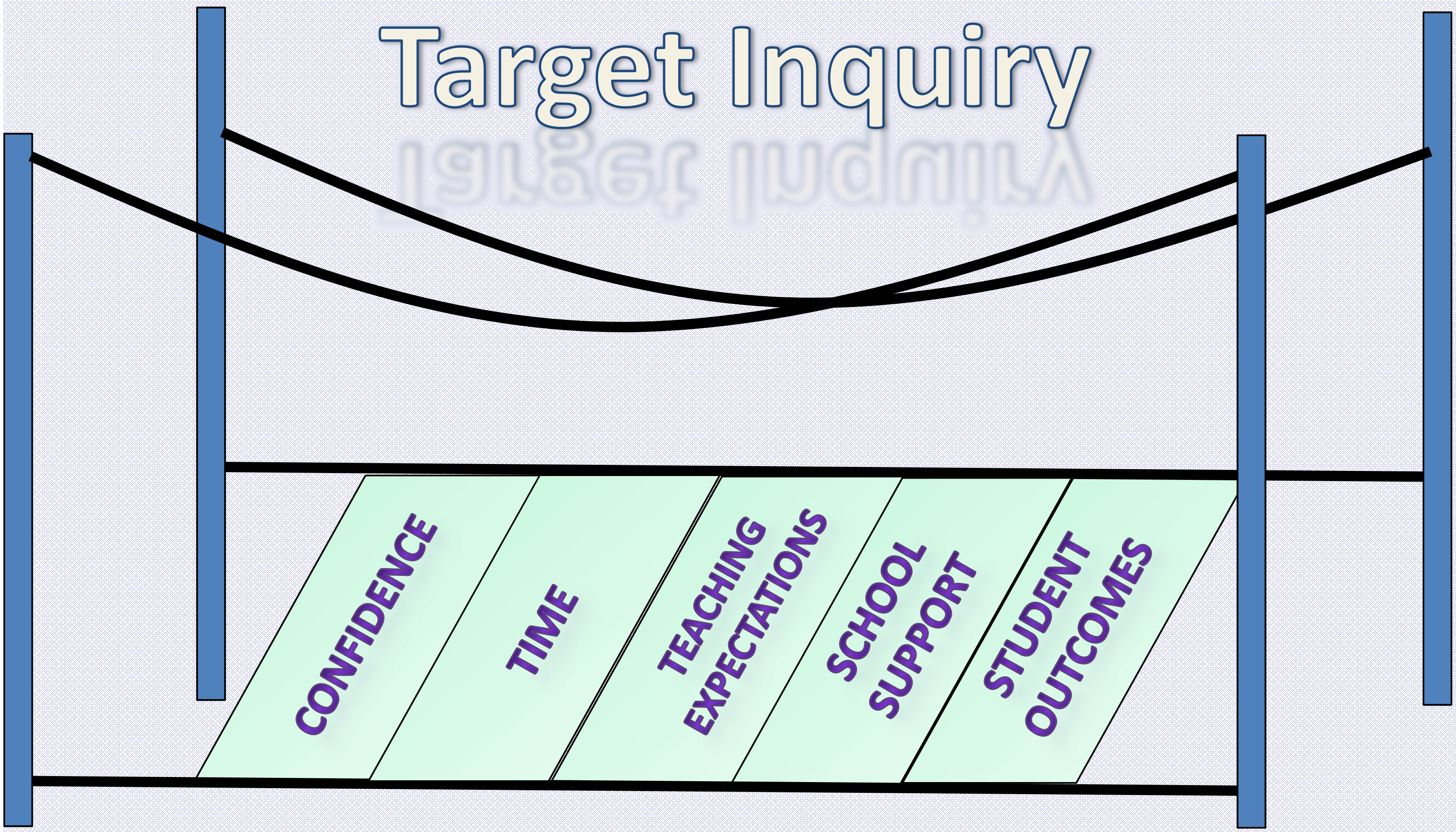
Frustration and Resolution

- **…they would get more frustrated with me than when they were doing a cookbook lab** [where] they kind of knew what they were supposed to get at the end. … **but then when they get to the end of the inquiry and we come together … they usually feel better,** and they've learned the concept more than if they are just doing the cookbook. (Teacher D, post CD)
- You know, people have been talking in our group about how **kids complain at first that inquiry's harder and stuff, but I started the whole year off with that density lab. … they never knew any different.** (Teacher B, post CD)
- **They get more frustrated with me! They think I'm not helping them.** … Sentiments like, **"You're supposed to tell me how to do this! You're supposed to be teaching me, you're a teacher. Don't they pay you to teach?"** (Teacher G, post CD)

TI: Bridge to Reformed Teaching

- But what TI did for me is **bridge the gap between what I think and believe and what I practice**…And it also not only started to bridge that gap, it's given me the tools that I can see one of these days, they **may actually meet each other**, and that's exciting to me. (Teacher B, post CD)
- I think back then I would have argued that active learning is where students are engaged in what they're doing. That they're discovering things on their own versus the teacher just telling them. … That part I don't think has changed. **I think that I would argue that was true before, but again I didn't know how to do that.** (Teacher A, post CD)
- I'm always aware of "I could try and do this better. I wish I could do that better" **but I think the program has given me some direction more.** Like I said, just about reporting back. Trying to get kids to think through every process. (Teacher P, post CD)

TI: Bridge to Reformed Teaching



Acknowledgments

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Dr. Caryn King

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Divya Gunda
Kristina Emery
Laura Kennedy
Cynthia Luxford
Ryan Wissner
Brittland Winters

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Discussion Questions

- How can we shift teacher PD toward long-term theory and data-driven models and away from brief "make-and-take" experiences? What are the political and institutional barriers to transforming PD?
- What's next for us and many projects represented here? In other words, what are logistical concerns for the scale-up and dissemination of new PD models? How can the DRK-12 community have a coordinated impact on a national level?