What Can I Do with All These Numbers? Exploring STEM Dataset Use

Andria Schwortz
Andrea Burrows
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UNIVERSITY OF WYOMING

Motivation

- Datasets are ubiquitous in STEM – and life!
- Little formal training in using datasets (Johri & Olds, 2014)
- Research exists on computational thinking and programming skills, but little on data management tools (Krajcik & Mun, 2014)
- Astronomy as the tool due to popularity, lower math level, "gateway drug"

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Research Question

- Can this 1.5-hour three-phase activity impact short-term learning?

Also, learning by…

1. Gender and undergraduate/science educator status
2. Novice (recall) vs. expert (synthesis) questions
3. Skills vs. content

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Sample

	Male	Female	Total
I. Undergraduates	**34**	**18**	**54***
A. Summer Astro course	5	2	7
B. Summer online Astro course	4	3	7
C. Fall Astro course	25	13	40*
II. Science Educators	**16**	**17**	**33**
A. PD 1	6	2	8
B. PD 2	4	4	8
C. PD 3	3	7	10
D. Science Writers	3	4	7
Total	**50**	**35**	**87***

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Astronomy Context: Quasars

- Extremely bright
- Most massive host galaxies
- Visible to large distances
- Trace the history of galaxy evolution
- Why do only some have jets?
- What can their distribution tell us about history of galaxies in the universe?

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Activity

- Pre-test
- Computer activity
- Data
  - Students: http://tinyurl.com/quasardata
  - Key: http://tinyurl.com/quasarkey
- Post-test

Gsheets, not Excel!

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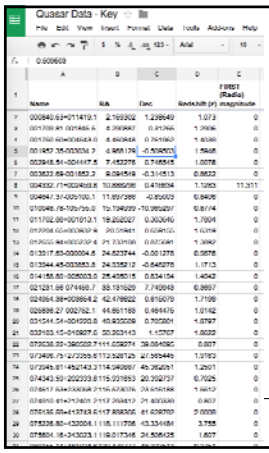
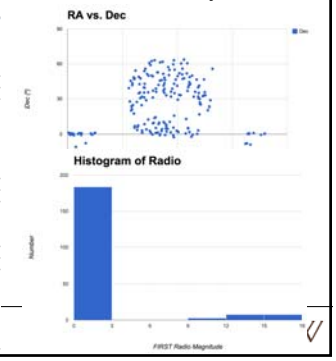
Astronomy Dataset Activity





Results

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Overall Learning: Pre/Post Test %

	Male	Female	Total
I. Undergraduates	57±19 / 78±19	* 58±16 / 70±22 *	58±18 / 75±20
II. Science Educators	73±20 / 91±10	57±27 / 85±13	65±25 / 88±11
Total	62±21 / 82±18	58±22 / 78±20	61±21 / 80±18

Scores went up

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Overall Learning: How much did they improve?

	Matched Normalized Gains			Effect Size (Cohen's d)		
	Male	Female	Total	Male	Female	Total
I. Undergraduates	0.467	0.084	0.285	1.12	0.62	0.86
II. Science Educators	0.438	0.475	0.457	1.18	1.37	1.22
Total	0.458	0.274	0.350	1.06	0.96	0.96

Gains (PER): Fraction of what could have been learned

Effect Size (ER): Standard deviations learned

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Q1) Female Undergraduates

	Male	Female	Total
I. Undergraduates	57±19 / 78±19	* 58±16 / 70±22 *	58±18 / 75±20
II. Science Educators	73±20 / 91±10	57±27 / 85±13	65±25 / 88±11
Total	62±21 / 82±18	58±22 / 78±20	61±21 / 80±18

Female undergraduates' learning not statistically significant

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Female Undergraduates

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II. Science Educators	0.438	0.475	0.457	1.18	1.37	1.22
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Female undergraduates' gains and effect size low

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Was it small number statistics?

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Comparable number of female undergrads to male or female science educators

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Q2) Novice vs. Expert

Novice/Recall	Male	Female	Total
I. Undergraduates	43±21 / 59±22	40±19 / 61±18	43±20 / 59±21
II. Science Educators	52±21 / 63±13	40±18 / 69±11	45±20 / 66±12
Total	46±21 / 60±20	40±18 / 65±15	44±20 / 61±9
Expert/Synthesis	**Male**	**Female**	**Total**
I. Undergraduates	13±7 / 17±8	* 12±8 / 16±9 *	13±7 / 17±8
II. Science Educators	17±9 / 23±4	13±11 / 22±7	15±10 / 23±6
Total	14±8 / 19±8	12±9 / 19±9	13±8 / 19±8

Higher scores in novice/recall than expert/synthesis

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Simultaneous improvement on Novice and Expert

All (N=87)		Novice/Recall -	0	+
Expert/ Synthesis	-	1 1%	1 1%	10 11%
	0	4 5%	13 15%	13 15%
	+	3 3%	12 14%	30 34%

Crosstabs: Table comparing how many people in two different categorization schemes.

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Q3) Skills vs. Content

Skills (Datasets)	Male	Female	Total
I. Undergraduates	63±20 / 81±25	* 68±22 / 69±25 *	66±21 / 76±26
II. Science Educators	73±21 / 84±15	59±22 / 79±20	66±22 / 82±18
Total	67±21 / 82±23	64±22 / 74±23	66±21 / 78±12
Content (Astronomy)	**Male**	**Female**	**Total**
I. Undergraduates	28±15 / 46±13	30±13 / 40±17	29±14 / 44±15
II. Science Educators	42±14 / 59±7	32±24 / 51±11	37±20 / 55±10
Total	33±16 / 50±13	31±19 / 46±15	32±17 / 48±14

Higher scores in skills than content

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Simultaneous improvement on Skills and Content

All (N=87)		Skills -	0	+
Content	-	3 3%	3 3%	0 0%
	0	2 2%	14 16%	4 5%
	+	3 3%	14 16%	43 49%

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Conclusions

- Overall participants exhibited (astronomy dataset) learning
- Non-sequential novice (recall) and expert (synthesis) learning dominated
- Both undergraduates and science educators need both skills and content instruction
- Female undergraduates struggled to learn

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Discussion: Female Undergraduates

- Challenges faced by females in STEM are well-known, but unsolved (Hill, Corbett, & St Rose, 2010; Microsoft, 2017)
- Leaky pipeline
  - Were the female science educators the survivors?
- Gendered language among undergraduates – male jokes (external), female poor self-assessment (internal)
  - Are male science educators more mature?
- Females undergraduates in mixed-gender groups never touched the computer (Day, et al., 2016)

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Teaching Takeaway

- Students can – **and should** – be taught to use datasets
- Female students need additional supports
  - Group assignments (gender, roles)
  - Metacognition of computer usage
  - Classroom management of gendered language
  - Always: female role models

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Recent/Upcoming Work

- Schwortz, Burrows, & Guffey. (2016) Mentoring Partnerships in Science Education. *Educational Action Research.* https://arxiv.org/abs/1610.04808
- Schwortz & Burrows. (*in prep*) What Can I Do With All These Numbers?: Exploring STEM Dataset Use. *Journal of Science Education and Technology.*
- Schwortz & Burrows. (*in prep*) Qualitative component of this work.

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Further questions?

aschwortz@qcc.mass.edu

Slides for this talk, electronic versions of the lesson plan, etc.

http://physics.uwyo.edu/~aschwortz

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