JOURNAL OF MICROBIOLOGY & BIOLOGY EDUCATION
DOI: https://doi.org/10.1128/jmbe.v18i2.1260

JMBE Journal of Microbiology & Biology Education

Supplemental Materials

for

Each to Their Own CURE: Faculty Who Teach Course-Based Undergraduate Research Experiences Report Why You Too Should Teach a CURE

Erin E. Shortlidge[1,2], Gita Bangera[3], Sara E. Brownell[1]*
[1]School of Life Sciences, Arizona State University, Tempe AZ, 85281, [2]Currently: Department of Biology, Portland State University, Portland, OR 97201, [3]WISE Institute, Bellevue College, Bellevue, WA 98007

Table of Contents

(Total pages 9)

*Corresponding author. Mailing address: School of Life Sciences, Arizona State University, 451 E. Tyler Mall, Tempe AZ, 85281. Phone: (480) 965-0803. Fax: (480) 965-6899. E-mail: sara.brownell@asu.edu.
Received: 28 October 2016, Accepted: 17 February 2017, Published: 26 May 2017.

Appendix 1: Participant demographics.

Appendix 1 – Table 1. Participant demographics.				
Demographic	**Number (n=61)**	**Overall Percent**	**Develop (n=39)**	**Implement (n=22)**
Female	38	62%	64%	59%
Male	23	38%	36%	41%
Professor	12	20%	21%	18%
Associate Professor	19	31%	33%	27%
Assistant Professor	14	23%	33%	5%
Instructor	16	26%	13%	50%
Tenure-Track	37	61%	72%	41%
Non Tenure-Track	24	39%	28%	59%
Mostly Teaching Expectations	43	70%	38%	86%
Mostly Research Expectations	18	30%	62%	14%
Upper Division Course	24	39%	38%	0%
Lower Division Course	37	61%	62%	100%
General Biology Course	21	34%	15%	68%
Ecology Course	13	21%	30%	5%
Microbiology Course	11	18%	21%	14%
Molecular Course	8	13%	13%	14%
Genetics Course	5	8%	13%	0%
Specialty Course	3	5%	8%	0%
PhD Granting	24	39%	38%	41%
Master's Granting	17	28%	31%	23%
Bachelor's Granting	13	21%	26%	14%
Associate’s Granting	7	11%	5%	23%
Years teaching a CURE	$\bar{x}$ = 4.9 ± 3.4		$\bar{x}$ = 6.4 ± 3.5***	$\bar{x}$ = 2.1 ± 1.3***
Basic Research Publications	Total 31 ($\bar{x}$ = 2.2 ± 1.4)		$\bar{x}$ = 2.4 ± 1.4	$\bar{x}$ = 1.6 ± 1.1
Education Research Publications	Total 30 ($\bar{x}$ = 1.7 ± 1.4)		$\bar{x}$ = 1.6 ± 1.5	$\bar{x}$ = 0.9 ± 0.3

Results are presented from interviews with 61 faculty members who have either developed an independent CURE ($n = 39$) or implemented a network CURE ($n = 22$). Participant demographic details including their gender, position, primary role (mostly research or mostly teaching), tenure status, course type, and course level are summarized in Appendix 1, Table 1 as a whole and disaggregated by CURE type. For numerical data (years teaching a CURE, and publication numbers), we report number, data mean and standard deviation. The mean number of years that all participants have been teaching CUREs was 4.9 (± 3.6 SD) with the minimum being one and the maximum being 16 years. There is a significant difference between the mean number of years our participants have been teaching CUREs based on if they have developed a CURE (6.4 ± 3.5 SD), or implemented a CURE (2.1 ± 1.3 SD; $t = -5.3$; $p < 0.0001$, $n = 60$). Participants reported the total number of basic science research publications resulting from CUREs as 31 publications (mean = 2.2 ± 1.4 SD), and the total number of education research publications resulting from CUREs was 30 (mean = 1.7 ± 1.4 SD); publication numbers do not differ significantly between individuals by CURE type. Data represent each individual's statements regarding their own publications and one or more of the reported publications may have been authored by more than one of our participants. In order to ensure requisite participant confidentiality, we do not report further participant-specific results.

Appendix 2: Additional methods and response categories by faculty position.

Additional Methods

Contingency analyses were conducted to identify if any of the following factors statistically predicted participants' coded responses: institution-type, course topic, course level (introductory or upper division), gender, professional rank, whether the faculty member has a primarily teaching or researching position, and their tenure-track status. Regressions or t-tests were used to identify if resulting publications from CUREs, and number of years teaching a CURE vary by participant demographics.

Tangible and Intangible statements

The most "tangible" statements made by any one participant was five: this individual cited one or more faculty- and student-centered tangible motivations for implementing/developing a CURE, they stated one or more faculty-centered tangible benefits from CUREs (no student-centered tangible benefits were cited as benefits to faculty from implementing/developing CUREs), and they made one or more faculty- and student-centered tangible statements in their pitch for a CURE. The highest intangible statement number was also a five. This individual offered both intangible faculty- and student-centered responses as their motivations to teach a CURE as well as in their pitch to a colleague for a CURE, and they made one or more faculty-centered intangible benefit statements.

Appendix 2 - Table 1. Faculty motivations for teaching a CURE by CURE-type and faculty position.

Motivations for Teaching a CURE

CURE Type	**Position**		**Tangible**			**Intangible**		
			Student-centered	Faculty-centered	All Tangible	Student-centered	Faculty-centered	All Intangible
Develop	Instructor	*n = 5*	1	2	3	1	3	4
		%	20	40	60	20	60	80
	Assistant	*n = 13*	4	9	10	2	8	11
		%	31	69	77	15	62	85
	Associate	*n = 13*	8	6	11	6	5	9
		%	62	46	85	46	39	69

	Professor	*n = 8*	2	3	4	4	2	5
		%	25	38	50	50	25	63
Total		*n = 39*	15	20	28	13	18	29
		%	**38***	**51***	**72****	33	46	74
Implement	Instructor	*n = 11*	3	2	5	3	7	8
		%	27	18	46	27	64	73
	Assistant	*n = 1*	0	0	0	1	1	1
		%	0	0	0	100	100	100
	Associate	*n = 6*	0	3	3	1	3	3
		%	0	50	50	17	50	50
	Professor	*n = 4*	0	0	0	2	3	4
		%	0	0	0	50	75	100
Total		*n = 22*	3	5	8	7	14	16
		%	**14***	**23***	**36****	31	64	72
Overall		*n = 61*	18	25	36	30	32	45
		%	**30**	**41**	**59**	**33**	**52**	**74**

* Indicates p-value ≤0.05; ** Indicates p-value ≤ 0.01. Statistical differences are specific to the difference between those teaching each CURE type (develop or implement) at each category.

Appendix 2 - Table 2. Faculty benefits from teaching a CURE by CURE-type and faculty position.

Benefits from Teaching a CURE								
CURE Type	**Position**		**Tangible**			**Intangible**		
			Student-centered	**Faculty-centered**	**All Intangible**	**Student-centered**	**Faculty-centered**	**All Intangible**
Develop	Instructor	n = 5	0	2	2	0	5	5
		%	0	40	40	0	100	100
	Assistant	n = 13	0	8	8	2	9	9
		%	0	62	62	15	69	69
	Associate	n = 13	0	8	8	2	11	11
		%	0	62	62	15	85	85
	Professor	n = 8	0	7	7	1	6	6
		%	0	88	88	13	75	75
Total		n = 39	0	25	25	5	31	31
		%	0	**64*****	**64*****	13*	79	79
Implement	Instructor	n = 11	0	1	1	5	10	11
		%	0	9	9	46	91	100
	Assistant	n = 1	0	0	0	0	1	1
		%	0	0	0	0	100	100

	Associate	n = 6	0	4	4	2	5	5
		%	0	67	67	33	83	83
	Professor	n = 4	0	0	0	1	3	4
		%	0	0	0	25	75	100
Total		n = 22	0	5	5	8	19	21
		%	0	**23*** **	**23*** **	36*	86	95
Overall		n = 61	0	30	30	13	50	52
		%	**0**	**49**	**49**	**21**	**82**	**85**

*** indicates p-value ≤0.003; * Indicates p-value ≤ 0.05.

Appendix 2 - Table 3. Faculty pitches to a colleague for teaching a CURE by CURE-type and faculty position.

Pitch for Teaching a CURE

CURE Type	**Position**		**Tangible**			**Intangible**		
			Student-centered	Faculty-centered	All Tangible	Student-centered	Faculty-centered	All Intangible
Develop	Instructor	*n = 5*	1	1	2	1	2	3
		%	20	20	40	20	40	60
	Assistant	*n = 12*	1	3	3	2	7	8
		%	8	25	25	17	58	67
	Associate	*n = 13*	5	4	7	3	7	9
		%	39	31	54	23	54	69
	Professor	*n = 7*	0	4	4	1	4	5
		%	0	57	57	14	57	71
Total		*n = 37*	7	12	16	7	20	25
		%	19	32	43	19	54	68
Implement	Instructor	*n = 10*	2	1	3	1	7	7
		%	20	10	30	10	70	70
	Assistant	*n = 1*	0	0	0	1	1	1
		%	0	0	0	100	100	100
	Associate	*n = 6*	0	4	4	1	3	3
		%	0	67	67	17	50	50
	Professor	*n = 4*	2	0	2	1	1	2
		%	50	0	50	25	25	50
Total		*n = 21*	4	5	9	4	12	13
		%	19	24	43	19	57	62
Overall		*n = 58*	11	17	25	11	32	38
		%	**19**	**29**	**43**	**19**	**55**	**66**

Appendix 3: Exploratory factor analysis and results.

Methods

Since the dataset as a whole had many potentially interacting factors to consider, we wanted to visualize patterns or underlying constructs to help us better understand some of the drivers of the data. To examine the numeric aspects of the data, we conducted an exploratory factor analysis (EFA). An EFA is a multi-variate statistical technique that enables exploration of any underlying correlations among variables within a dataset. EFA takes into account the factors used in the model and identifies any linear correlations among various factors for each individual in the dataset, allowing for a more holistic understanding of the drivers of emergent trends. EFA is performed when researchers make assumptions that there is some sort of underlying driver that can describe the data. Using the following factors, we performed an EFA using the recommended Varimax rotation for maximum likelihood (Ellison and Gotelli 2004), allowing us to look for underlying constructs and/or key variables that characterized the numeric data. Variables used in the EFA included the following for each participant: the number of years they had been teaching CUREs, the number of basic science research publications resulting from a CURE, the number of education research publications resulting from CUREs, faculty and student-centered tangible and intangible statements, as well as their institution's level of research intensity. Institutional research level was determined by ranking institutions on a scale of 1-4 from least research-intensive to most research-intensive: (1) community college, (2) bachelor's granting, (3) master's granting, and (4) PhD granting institutions. Though this is a coarse view of research intensity, it is in alignment with general classifications in rankings of higher education by the *Carnegie Classification of Institutions of Higher Education* ™. The data were square root transformed in order to normalize the numerical data before analysis. Total tangible and total intangible statement numbers were not used in the final factor analysis, as preliminary factor analyses indicated that they were both highly correlated (>0.80) with their respective faculty-centered statements, thus were dropped from the model. All data analyses were conducted using *JMP 11 (SAS Institute 2012)* and *GraphPad Prism 6* (*GraphPad Software Inc*.).

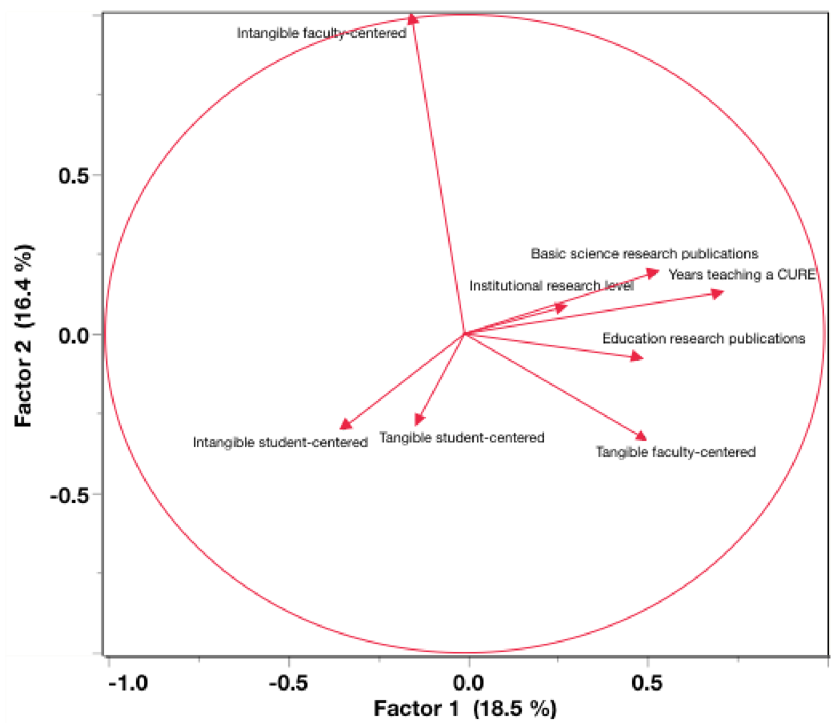
Results

The EFA illustrates explanatory correlations within the numeric factors of our dataset. This analysis gives a snapshot of a large portion of the data all in one figure, which would otherwise be difficult to identify. We used recommended protocols for conducting EFA outlined in (Ellison and Gotelli 2004). Our EFA does not display particularly robust factors (Factor 1 explains 18.5% of the variance in the data, Factor 2 explains 16.4% of the variance in the data; see Supplemental Table 4 for factor loadings), but the purpose of the analysis was to visualize underlying patterns in the data that would be difficult to detect otherwise, and the resulting factor loading plot is thus informative (Figure 4). The analysis provides insight into trends within our dataset, as well as highlights areas for future investigation on CURE-teaching faculty. For example, Factor 1 (vectors along the horizontal axis) show a positive relationship between the number of years a participant has been teaching CUREs and the number of both education and basic science research publications participants reported to result from CUREs. These positively correlated factors are in opposition to the prevalence of participants reporting a high number of intangible student-centered statements. Using these data, one could now propose hypotheses to guide future studies. For example, based on the results of this EFA, we might predict that faculty who teach CUREs primarily in the interest of improving student engagement (intangible student-centered), are less likely to publish on CURE-collected data than those who cite faculty-centered motivations for teaching CUREs.

Appendix 3 – Table 1. Factor loadings for each of the variables in the exploratory factor analysis, the two factors were rotated for maximum likelihood using Varimax rotation.

Variable	Factor 1	Factor 2
Institutional research level	0.2691	0.0821
Years teaching a CURE	0.7064	0.1281
Basic science research publications	0.5267	0.1907
Education research publications	0.4813	-0.0756
Tangible student-centered	-0.1290	-0.2698
Tangible faculty-centered	0.4964	-0.3266
Intangible student-centered	-0.3358	-0.2942
Intangible faculty-centered	-0.1465	0.9892

Appendix 3 - Figure 1. Factor analysis.



Underlying patterns among CURE instructors

By examining underlying patterns in the data, we can gain insight into who publishes peer-reviewed manuscripts using data resulting from or about their CUREs. In Figure 4, we show a positive correlation between participants who made more intangible faculty-centered statements about CUREs, and their total number of CURE research publications. While we did not ask participants why they publish, Chen et al., (2006), reported that tenured faculty were motivated to publish by intangible factors, while pre-tenure faculty claimed tangible motivations (including tenure) for publishing. The analysis also shows that there is a positive correlation between the number of years an individual has been teaching CUREs, and the number of CURE-based publications. We also found that the individuals publishing the most from their CUREs are moderately positively correlated with increasing level of research-focus at their institutions (Figure 4). Future work could focus on CURE instructors' specific motivations to publish from CUREs, and if those intentions to publish come to fruition.