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Fostering an Enriching Learning Experience: A Multisite Investigation of the Effects of Desktop Learning Modules on Students' Learning Experiences in Engineering Classrooms

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Fostering an enriching learning experience: a multisite investigation of the effects of desktop learning modules on students learning experiences in engineering classrooms.

Abstract

Several studies have demonstrated that active learning methods prime students to learn better in the classrooms. As part of an initiative to advance efforts to promote active learning facilitated using hands-on learning modules, we have been conducting research on the effects of desktop learning modules (DLMs) on the learning experiences of students in engineering classrooms. We reported the effect of using DLMs on students' motivations and learning strategies skills at the ASEE 2015 conference. However, in this follow-up study, we report a multi-site implementation of DLMs on the learning experiences of a different cohort of students. We examined the robustness of the effects of using DLMs on student learning motivation and learning strategies across multiple learning contexts. We also examined their effect in situational interest development in the classroom.

Using data from 50 participants, this paper reports the effects of DLM-facilitated instruction on students learning experience. Participants were undergraduate students who enrolled in heat transfer courses in two universities in the United States. Participants first learned concepts of heat transfer using DLMs and then took inventories of motivation and situational interest. Results of the analyses showed similarities in DLM effect on students' motivation and use of learning strategies across the two universities. We found no significant difference in gender across participants. The paper concludes with a discussion of effects of the implementation of DLM on situational interest development with participants across the two universities.

Keywords: motivation; desktop learning module; hands-on learning; active learning

Introduction

Numerous research studies have shown that the traditional lecture-style approach to engineering pedagogy is sub-optimal to fostering student engagement and meaningful learning [1]. Some reports have also indicated that students' motivation for learning engineering concepts are on the decline – the result of which is observed in a progressing pattern of low student-retention in engineering programs [2, 3]. However, dwindling student retention in STEM and engineering programs could undermine our strategic national objective of training and graduating a sufficient pool of science and engineering personnel to minimize a STEM professional deficit. Researchers have proposed and studied several approaches to fostering student engagement within and beyond the classroom. In some cases, entire curricular changes are proposed to promote 'pedagogies of student engagement' in the classroom [4]. While others have explored efforts to promote engagement and foster the development of an engineering career identity by providing students with experiential and service learning opportunities beyond the classroom [5].

Some studies have shown that developing instruction around hands-on activities can promote student engagement and meaningful learning in the classroom [6, 7]. As part of an initiative to promote active learning engagement facilitated using hands-on learning modules in engineering classrooms, we have been studying the cognitive and affective affordances of Desktop Learning Modules (DLMs) for engineering concepts instruction and learning. DLMs are hands-on teaching aids that can simulate different engineering concepts. Students can manipulate and observe them in learning some abstract engineering concepts in the classroom. Figure 1 below is an example of a module we used in the past studies. The low cost DLMs versions that we used in our studies are simple and inexpensive to construct and are made from off-the-shelf materials. Students can see through them and they cost and weigh less than a textbook.

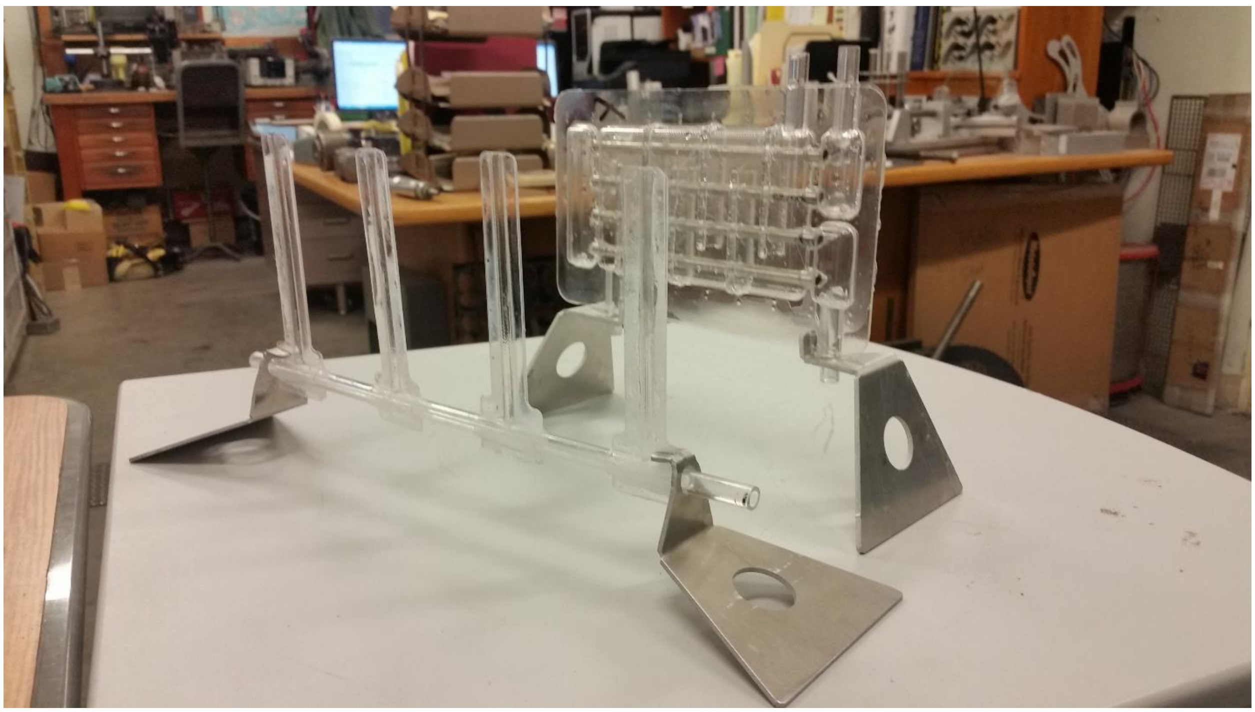

Fig. 1: Sample Low Cost desktop learning module

Our research assumptions are that infusing active learning into the learning experiences of students, as opposed to the traditional lecture-alone instruction, would promote learning interests, motivation, and encourage students to engage in self-regulatory and metacognitive strategies that promote learning gains.

At the ASEE 2015 conference, we reported a study that compared the effects of DLM-facilitated instruction and lecture-alone on students' motivations for learning and learning strategies [8]. While we found no significant DLM effects on students' motivation to learn, student self-report indicated that the DLM experience seemed to promote three learning strategies – elaboration, critical thinking and peer learning – better than lecture alone. In this follow-up study, we examine effects of DLM-facilitated instruction on the learning experiences of a different cohort of students in a multi-site implementation. The intent is to examine the robustness of the DLM effect on promoting learning benefits in students across multiple learning contexts, especially when implemented by people outside our research team. We examined whether DLM effects were similar on situational interest and positive learning strategies for students in different learning contexts who experienced similar DLM-facilitated instruction.

Motivated Strategies for Learning

Self-regulatory and meta-cognitive strategies have been construed as very crucial to promoting leaning engagement and academic achievement [9]. This is premised on the constructivist view of learning that meaningful learning does not result from passive accumulation of facts via rote memorization. Rather, it is the product of purposeful involvement in activities geared at active knowledge construction [10]. The active learning literature has indicated that while students may be less engaged with the learning process in the traditional lecture classroom, thoughtfully implementing hands-on instruction facilitates behavioral and cognitive engagements that promote meaningful learning [11].

We envisaged that using DLMs to facilitate the teaching of engineering concepts would promote active and meaningful engagement in our classrooms. As a result, beyond only seeking evidences of direct cognitive learning gains from implementing DLMs, we have sought to explore whether the DLM experience has measurable effects on students motivated strategies for learning. Three learning strategies measures were selected from the Motivated Learning Strategies Questionnaire (MSLQ) to assess students learning strategies.

Situational Interest

Interest describes one's affection for, and disposition to re-engage with objects or activities within one's own environment [12]. Research has indicated that interest plays a pivotal role in the early stages of learning. Some have even argued that one could differentiate experts from other moderately skilled performers by how much interest they exhibit [13] On the one hand, interest may be an inherent trait (e.g. personal interest in science) that learners bring to the classroom [12, 14]. On the other, the learning activities or environment may also be an interest trigger for some not had shown much any considerable interest in a learning activity [15]. Interest triggered by elements of the learning environment is referred to as *situational interest* [12]. Unlike personal interest, situational interest is transient and dependent upon other environmental factors [12, 16]. However, it is capable of instigating eventual personal interest, as much as promoting positive learning behaviors and academic achievement [15].

Extant models of interest development argue that personal interest evolves from a transient triggered state into more stable interest forms over time [12]. Theorists propose two states of situational interest: *triggered* and *maintained* situational interest, which results from positive affective response to some features of the learning situation [12, 17]. Although transitory in nature, triggered situational interest could evolve into a more stage form of maintained situational interest through the agency of factors in the learning environment designed to promote meaningful and engaging learning tasks [12, 18]. Situational interest, if maintained, could emerge into more stable forms of personal interests as the learner begins to cognitively internalize and personalize their reason for engaging with associated learning tasks [12]. Some have proposed that incorporating hands-on learning in the classroom are among sources of triggering situational interest and fostering engagement in uninterested students [18]. Because situational interest is highly dependent on environmental contexts, we were interested in examining whether DLM-facilitated instruction would comparably induce triggered situational interest in participants at the two far removed sites.

Objective of this study

This is a follow-up study designed across two sites to examine the implementation of DLMs on the learning experiences of different cohort of students. We examined the robustness of the effects of using DLMs on student learning motivation and learning strategies across these multiple instructional contexts. The study is part of a research agenda aimed at evaluating the cognitive and non-cognitive affordances of DLM-facilitated instruction on desirable learning outcomes. In a previous study, we reported a study comparing the DLM effect on the motivations and learning strategies of students who experienced DLM-instruction to those who had lecture alone [8, 19]. We had also examined the effect of DLM intervention on perceived situational interest in students in another study [20].

Method

Participants

Participants were 50 undergraduate engineering students who enrolled in similar Heat Transfer courses at two public universities in the South-central (n = 23) and the Pacific Northwest (n = 27) regions of the USA. The participants included 9 female students, majority (n = 41) are in the junior year of their engineering degree programs. Both groups have experienced heat concept instructions based on DLMs in their classrooms in the same spring semester of 2016. DLMs were used to teach selected heat transfer concepts at each school. Instruction time in both classes lasted for 50 minutes per class period.

Materials

Online Survey. Participants responded to online survey statements using a 7-point Likert scale (1 = not at all true of me, 7 = very true of me) self-report of how the intervention has influenced them. Situational interest was assessed using a situational interest survey adapted from earlier instruments [17, 18] to reflect the learning activity. Triggered situational interests sub-scales comprised 4 items respectively, while two forms of maintained (feeling-based and Value-based) situational interests maintained sub-scales comprised of 4 items each. The other subscales include: critical thinking (4 items), metacognitive self-regulation (4 items) and peer learning (3 items).

Desktop Learning Module

The DLMs used in these studies are miniaturized low-cost shell and tube and venturi instructional aids intended to simulate temperature, pressure and flow rates. Figure 2 below is a sample of a shell and tube used in our study. Participants could simulate different flow rates and observe how temperature and pressure changes as fluids pass through the system. Using shell and tube equations, for example, they could explore different scenarios to better appreciate the relationship between shell and tube concepts. As teaching aids, DLMs provide visual reinforcements that substantiates many of the abstract concepts taught in the classroom as students interact with the system.

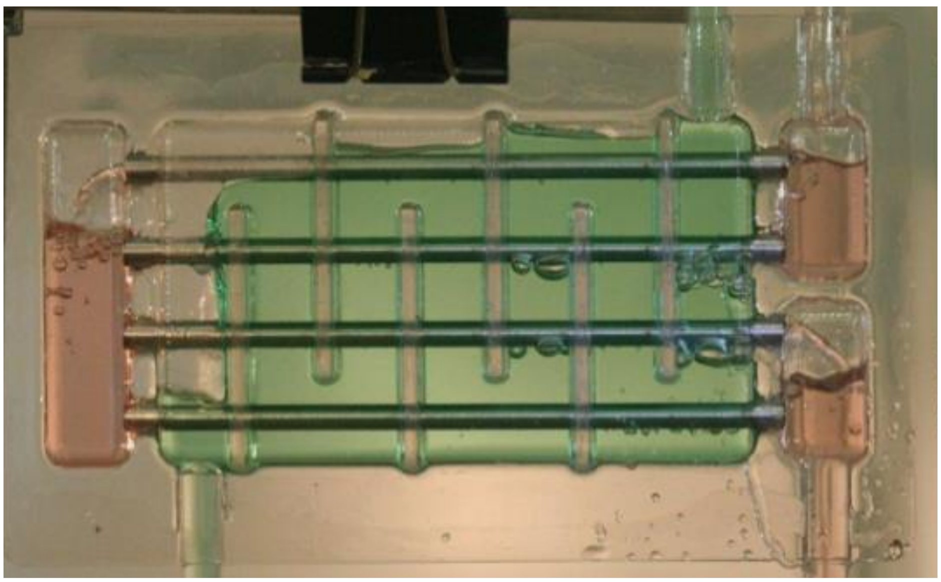

Figure 2: Sample of shell and tube used in the current study

Procedure

The classroom sessions involved 50-minutes weekly instruction on concepts in heat transfer taught using hands-on learning modules on the two campuses. The instructor in each school used DLMs to facilitate instruction while teaching heat transfer and fluid mechanics concepts. Students on both campuses received links to an online survey administered via Qualtrics© at end of the DLM sessions at each school. The survey prompts asked participants to reflect on their lecture and DLM-facilitated instructions and report how well they believed experiencing DLM-instruction motivated them to engage in statements of learning strategies or how DLMs engendered affective responses that we intended would capture situational interest.

Data Analysis & Results

Prior to comparison analyses, we conducted reliability analysis to assess the internal reliability coefficients of the subscales. Internal reliability measure estimates how correlated the items that are designed to measure the same construct are. A scale with Cronbach alpha of 0.7 and above is generally considered having a good reliability. Reliability coefficients and mean scores items on each of the sub-scales making up the survey are reported in Table 1 below.

Table 1: Descriptive and scale reliability statistics

Construct	Mean	SD	Cronbach's Alpha
Critical Thinking	18.38	4.44	0.83
Meta-cognitive strategies	18.420	4.17	0.71
Peer Learning	13.58	3.94	0.83
Triggered SI	11.46	5.49	0.92
Maintained feeling SI	19.30	5.12	0.85
Maintained value SI	20.60	4.53	0.88

Learning strategies

Table 2 shows the descriptive statistics (means and standard deviations) for the three learning strategies measured. Analysis of variance indicated that differences in DLM effects on *Critical Thinking* across both groups was insignificant ($F(1, 48) = 1.15$, $p = .29$). Similarly, DLM-effect on the groups were not different for Metacognitive Self-Regulation ($F(1, 48) = .01$, $p = .93$) and Peer Learning ($F(1, 48) = .79$, $p = .38$).

Table 2: A Comparison of students' perceptions of DLMs experience on learning strategies by site

	SITE I (n = 23)		SITE II (n = 23)			
	Mean	*SD*	*Mean*	*SD*	*F*	*Sig.*
Critical Thinking	19	3.08	17.65	5.64	1.15	0.29
Metacognitive Self-Regulation	18.37	3.36	18.48	5.02	0.01	0.93
Peer Learning	14.04	3.08	13.04	4.77	.787	0.38

We also examined whether there were differences in DLM effects on learning strategies based on gender. Table 3 shows a comparison of DLM effects on learning strategies across gender groups. Group mean scores on these measures were high, indicating construct desirability. No significant gender differences were observed on the three measures of learning strategies.

Table 3: A comparison of students' perceptions of DLM experience on learning strategies by gender

	Male		Female			
	Mean	*SD*	*Mean*	*SD*	*F*	*Sig.*
Critical Thinking	18.68	4.6	17.11	3.92	0.89	0.35
Metacognitive Self-Regulation	18.62	4.01	17.55	5.17	0.47	0.49
Peer Learning	13.75	3.65	13.33	5.19	0.08	0.78

Situational Interest

Table 4 shows the means and standard deviations for the three forms of situational interest measured. Analysis of variance indicated that differences in DLM effects in engendering triggered situational interest across both groups was insignificant ($F(1, 48) = 0.39$, $p = .53$). Similarly, DLM-effect to engender feeling-based maintained situational interest ($F(1, 48) = .005$, $p = .94$) and value-based maintained situational interest ($F(1, 48) = .10$, $p = .74$) were similar across both groups.

Table 4: A Comparison of students' perceptions of DLMs experience on situational interest by sites

	SITE I		SITE II			
	Mean	*SD*	*Mean*	*SD*	*F*	*Sig.*
Trigger Situ. Int.	8.11	4.07	9.04	4.80	0.55	0.46
Maintain_f_SI	15.03	3.40	15.26	3.70	0.23	0.63
Maintain_v_SI	20.41	4.22	20.83	4.96	0.10	0.75

Finally, we also examined whether there were gender differences in DLM effects to engender situational interest in participants. Male and female students did not differ on the measures of situational interests. (Table 5 shows descriptive statistics of the situational interest scores by gender). Similarly, high mean scores are indicative of construct desirability.

Table 5: A comparison of students' perceptions of DLMs experience on situational interest by gender

	Male		Female			
	Mean	*SD*	*Mean*	*SD*	*F*	*Sig.*
Trigger Situ. Int.	11.28	5.29	12.44	6.80	0.56	0.52
Maintain_f_SI	19.85	3.99	16.77	8.58	2.69	0.11
Maintain_v_SI	21.1	4.43	18.22	4.68	3.03	0.09

Discussion

This study is part of a large NSF-funded program of research that is examining the effects of using DLMs to engender undergraduate engineering students' motivation and facilitate their use of engaging learning strategies. As briefly reviewed in the introduction to this paper, the student motivation and deployment of learning strategies are powerful indicators of their actual learning [9]. Nevertheless, little is known in the engineering education literature about the robustness of this general findings. Hence, the present study seeks to fill an important gap in the literature. In previous work [19], we found that students' use of DLM for active learning promoted their use of effective study strategies such as elaboration, critical thinking and peer learning more than when the students learned with lecture alone. In the present study, we examined the robustness of the effects of using DLMs on students self-reported study strategies across two different institutions. Recently, some have raised issues about implementation fidelity with the deployment of educational interventions [21]. Hence, having instructors order than the initial developers implement an educational intervention could be critical to demonstrating the instructional efficacy of such intervention. The present study examined the comparative effects of DLMs at two difference sites – one where the developers facilitated the implementation and another site with no developers present but instructors followed implementation guidelines very closely. The goal, was to examine the robustness of the effects of DLMs on motivation and deployment of learning strategies across multiple learning contexts, especially when implemented by instructors outside our research team. In addition, we examined whether DLM effects were similar on situational interest across sites and gender.

Results showed similar DLM benefits in fostering student motivation and the use of engaging learning strategies among participants across the two sites. This finding suggests that DLMs may be effective educational interventions for promoting classroom engagement if implemented by other instructors under similar learning conditions. This is important considering that the goal of our research team is to expand the development of DLMs and encourage their use in more engineering programs nationwide. In addition, results did not show any significant differences due to gender. This finding, although preliminary suggests that the use of DLMs could be beneficial for females as they are for males, in fostering situational interests and learning strategies such as critical thinking, metacognitive self-regulation and peer learning. This is another important finding particularly as the field of engineering has witnessed dramatic gender gaps in retention and workforce development between males and females [22]. Beyond the close-ended survey items used in this study, students' and instructors' comments about their experiences using DLMs further corroborated our survey findings. However, we have limited our analysis to the close-ended survey in this report.

There are at least two limitations of this study that we would seek to address in future studies. First, the sample size is small. Hence, caution should be exercised in drawing conclusions from the findings. We would endeavor to conduct large scale studies of the robustness DLM effectiveness using a larger sample. Second, the lack of control groups limits the comparative analysis of the effects. Future studies would include a control group at each research site to ensure more rigorous DLM effect comparisons across groups. Nevertheless, the present study's findings are promising and would be further explored in future studies.

In sum, the present study is an important step in comprehensively examining the potential of broader dissemination of DLMs in engineering classes and ensuring fidelity of implementation across different sites. Our research team is looking to obtain more experimental data from different student populations, and across multiple engineering programs, to determine the robustness of the educational benefits of implementing DLMs in the engineering classrooms.

Reference

[1] R. M. Felder, Teaching engineering at a research university: problems and possibilities, Educacion Quımica, vol. 15 no. 1, pp. 40–42. 2004.

[2] D. Wilson, D., Jones, F. Bocell, J. Crawford, M. J. Kim, N. Veilleux, T. Floyd-Smith, R. Bates, and M. Plett, "Belonging and academic engagement among undergraduate STEM students: A multi-institutional study'" *Research in Higher Education,* vol. 56, pp. 750–776, 2015.

[3] L. L. Espinosa, "Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence." *Harvard Educational Review*, vol. 81 no. 2, 209–240, 2011.

[4] R. Lattuca, P. T. Terenzini and J. F. Volkwein, "Engineering Change: A Study of the Impact of EC2000," *International Journal of Engineering Education,* Vol. 20, No. 3, pp. 318-328, 2004.

[5] W. Oakes, J. Duffy, T. Jacobius P. Linos, S. Lord, W.W. Schultz, and A. Smith. "Service-learning in engineering," *Frontiers in Education,* vol. 6, pp. 6-9, Nov 2002.

[6] C. V. Smith, and L. Cardaciotto, "Is active learning like broccoli? Student perceptions of active learning in large lecture classes." *Journal of the Scholarship of Teaching and Learning,* Vol. 11, No. 1, pp. 53 – 61, 2011.

[7] G. Hampden-Thompson and J. Bennett, "Science Teaching and Learning Activities and Students' Engagement in Science." *International Journal of Science Education,* vol. 35 no. 1, pp. 1325-1343, 2013.

[8] N.Hunsu, B. Abdul, O. Adesope, B. J., Van Wie, G., Brown, "Exploring students' perceptions of an innovative learning paradigm in a fluid mechanics and heat transfer course," *International Journal of Engineering Education,* vol. 31 no. 5, pp. 1200 – 1213, 2015.

[9] M Credéa, and L. A. Phillips (2011). A meta-analytic review of the Motivated Strategies for Learning Questionnaire. *Learning and Individual Differences,* vol. 21, no 4, pp. 337-346.

[10] D. H. Schunk, "Learning theories: An educational perspective," 6th ed. Pearson: Boston, 2011.

[11] Goldberg, J. R. & Rank, D. B. "A hands-on, active learning approach to increasing manufacturing knowledge in engineering students. *American Society for Engineering Education,* June 2013.

[12] S. Hidi and K. A. Renninger, "The four-phase model of interest development"' *Educational Psychologist*, vol. 41 no. 2, pp. 111–127, 2006.

[13] S. Hidi and J. M. Harackiewicz, "Motivating the academically unmotivated: A critical issue for the 21st century, *Review of Educational Research*, Vol. 70, No. 2, pp. 151-179, 2000.

[14] K. A. Renninger, and S. Hidi, "Student interest and achievement: Developmental issues raised by a case study," in *Development of achievement motivation,* A. Wigfield & J. S. Eccles (Eds.), pp. 173–195, New York: Academic, 2002.

[15] G. Schraw, T. Flowerday, and S. Lehman, "Increasing situational interest in the classroom," *Educational Psychology Review,* vol. 13, no. 3, pp. 211–224, 2001.

[16] K. A. Renninger, and H. Hidi, "Revisiting the conceptualization, measurement, and generation of interest*." Educational Psychologist*, vol. 46, no. 3, pp. 168–184, 2011.

[17] L. Linnenbrink-Garcia, A. M. Durik, A. M. Conley, K. E. Barron, J. M. Tauer, S. A. Karabenick, et al., "Measuring situational interest in academic domains" *Educational and Psychological Measurement,* vol. 70, no.4, pp. 647–671, 2010.

[18] M. Mitchell, "Situational interest: Its multifaceted structure in the secondary school mathematics classroom," *Journal of Educational Psychology*, vol 85 no. 3, pp. 424–436, 1993.

[19] O. O. Adesope, N. J. Hunsu, B. J. Van Wie, "The effects of using desktop learning modules on engineering students' motivation," *American Society for Engineering Education Conference Proceedings,* Seattle, WA, 2015.

[20] N. J. Hunsu, O. Adesope, B. J. Van Wie, "Engendering situational interest in a hands-on learning classroom: What really matters?," *Instructional Science*, vol. 45 no. 6, pp. 789-804, (2017).

[21] B. Harn, D. Parisi, M. Stoolmiller, "Balancing fidelity with flexibility and fit: What do we really know about fidelity of implementation in schools?," *Council for Exceptional Children,* vol. 79 no. 2 pp. 181-193, 2013.

[22] J. J. VanAntwerp and D. Wilson, "Difference between Engineering Men and Women: How and Why They Choose What They Do during Early Career," *American Society for Engineering Education*, 2015.