Measuring Self-Efficacy in the Context of 3D/Virtual Technology Learning: Scale Development and Assessment

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Background and Objectives: Over the past decade, attention to 3D/virtual technology-related skill development within both industry and academia has significantly increased in fashion and textiles. To meet the workforce demands of technology-capable employees, educators have emphasized the importance of preparing students in 3D/virtual technology use (Hodges et al., 2020). Several instructional approaches have been created to enhance learning of 3D/virtual technology among students in apparel programs (Baytar, 2018; Park et al., 2011). Although undergraduate students have a great deal of exposure to technology and are assumed to be technology savvy, they may not be technically proficient with 3D/virtual applications (Gu et al., 2013). As such, it is important to create pedagogical approaches to developing and assessing students' proficiency in these technologies.

The concept of self-efficacy, or the judgments of one's capabilities to establish and perform a course of action, could provide a mechanism to explain students' confidence in their ability to master a 3D/virtual technology (Bandura, 1986). Bandura (2006) posited that self-efficacy can be an effective predictor of learning, which, in turn, affects students' academic success as well as workplace competencies. In addition, Dinther et al. (2011) stated that learning activities that are integrated with practical experiences are likely to produce a stronger sense of self-efficacy. Some research (e.g., Chang et al., 2019) has suggested that self-efficacy is not a unitary construct; instead, it can be content-specific in different domains (e.g., problem-solving or academic self-efficacy). Thus, the purpose of this study was to develop and test a self-efficacy measure relative to 3D/virtual technology learning for use within the apparel design and merchandising curriculum. The focus on 3D/virtual technology self-efficacy was framed by expectancy-value theory (Eccles & Wigfield, 2002). According to Eccles and Wigfield (2002), expectancies are "beliefs about how one will do on different tasks or activities, and values have to do with incentives or reasons for doing the activity" (p. 110). Expectancies for success may refer to one's self-efficacy or outcome expectations (Bandura, 1997). Wiebe et al. (2018) stated that expectancy-value theory supports to set self-efficacy related to both success expectancy in the certain academic domain and outcome expectancy regarding the value of this academic subject field to future goals. Given this theoretical perspective, 3D/virtual technology self-efficacy was defined as a judgment of an individual's capabilities to use this technology to accomplish education- and career-related tasks.

Two research objectives served as central motivations for this study. The first objective was to develop and validate an instrument assessing self-efficacy in 3D/virtual technology use within an apparel-related pedagogical context. The second objective was to test the instrument via an exploratory study to assess the effectiveness of learning activities designed to improve students' self-efficacy with using 3D/virtual technology. Findings from this pilot study will help educators better assess students' 3D/virtual technology learning and skill development.

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Method: Because a scale measuring self-efficacy in using 3D/virtual technology does not currently exist, an initial 27-item instrument was developed from the literature (Blomquist et al., 2016; Laver et al., 2012; McClough & Rogelberg, 2003; Riggs et al., 1994; Tatar et al., 2009). To test the instrument, educational materials focused on 3D/virtual technology were delivered into existing apparel design and merchandising programs at three U.S. universities. Two courses, one at the lower level and one at the higher level, were selected at each university. With IRB approval from the three universities, the instrument was administered as a pre-test prior to the learning activities and again as a post-test after activities were complete. A total of 92 matched pre- and post-tests were used for analysis. Exploratory Factor Analysis, Confirmatory Factor Analysis and reliability tests were conducted to identify the underlying structure and to examine the stability of the instrument (see Table 1). To test whether self-efficacy relative to 3D/virtual technology increased after completing class activities, paired-sample t-tests were conducted.

Table 1. The Results of Factor Analysis, Reliability, and Validity Tests

Items	Factor Loading	Reliability	Variance Extracted
Attitude Self-Efficacy		.814	57.512
I find learning 3D/virtual technology concepts to be challenging (r)	.801		
I find completing 3D/virtual technology assignments to be challenging (r)	.789		
I struggle to complete my 3D/virtual technology assignments without assistance (r)	.748		
I feel anxious about being asked questions on 3D/virtual technology when I am in the classroom environment (r)	.680		
I fear I will not be able to successfully complete 3D/virtual technology assignments (r)	.768		
Skill/Knowledge Self-Efficacy		.832	60.176
I cannot learn how to use 3D/virtual technology no matter how hard I try (r)	.824		
I cannot comprehend 3D/virtual technology no matter how hard I try (r)	.796		
I am confident that I can understand basic 3D/virtual technology concepts that are covered in class	.823		
I am confident that I can understand the most difficult 3D/virtual technology concepts that are covered in class	.679		
I am capable of improving my understanding of 3D/virtual technology	.747		
Comprehensive Self-Efficacy		.861	78.809
I have the skills required to successfully complete 3D/virtual technology assignments	.888		
I have the knowledge to comprehend 3D/virtual technology concepts	.892		
I can successfully complete 3D/virtual technology assignments	.884		

Results: Respondents' ages ranged from 18 to 24. The majority were Caucasian/ White (n = 67, 72.8%), followed by Hispanic (n=12, 13%). With respect to gender, the majority were female (n=76, 82.6%). The EFA resulted in 13 items out of 27 being retained after excluding items that cross-loaded and low factor loading (below 0.4) items. Three factors were identified as a result: *attitude self-efficacy*, *skill/knowledge self-efficacy*, and *comprehensive self-efficacy*. Results of the CFA indicated good model-data fit of the three dimensions of the self-efficacy structure (GFI=0.88, NFI=0.93, CFI=0.94, and TLI=0.92). All factors had reliabilities above 0.70. Average variance extracted (AVE) scores above 0.50 were used to establish convergent validity. Significant differences in the means were found for attitude self-efficacy and comprehensive self-efficacy, but not for skill/knowledge self-efficacy (see Table 2).

Table 2. The Result of Paired Samples T-Tests

	Paired Samples Test				
	Mean Difference (M_i - M_j)	SD	t	df	Sig.
Attitude Self-Efficacy	0.393	0.711	5.306	91	0.000***
Skill/Knowledge Self-Efficacy	0.024	0.621	0.369	91	0.713
Comprehensive Self-Efficacy	0.348	0.892	3.723	90	0.000***

Note: M_i is a mean of the post-test result M_j is a mean of the pre-test result; *** p <0.000

Discussion and Implications: Three factors of 3D/virtual technology self-efficacy were revealed in this study. First, attitude self-efficacy, which explains one's belief about their ability to use

3D/virtual technology. Second, skill/knowledge self-efficacy, which explains one's perceived skill/knowledge about 3D/virtual technology. Third, comprehensive self-efficacy, which is an overall evaluation of one's self-efficacy in using 3D/virtual technology. In view of the expectancy-value theory, the three self-efficacy factors reflect both success and outcome expectancies relative to 3D/virtual technology. Interestingly, results indicate that the levels of attitude self-efficacy and comprehensive self-efficacy increased after the learning activities were completed, but the level of skill-knowledge self-efficacy did not. This finding suggests that the instrument may be better used to test self-efficacy relative to learning outcomes that are content specific rather than technology specific.

Implications and Future Research: This study was an exploration and assessment of an instrument designed to assess 3D/virtual technology learning through measuring self-efficacy. As this study was designed as a pilot test of the developed instrument, further refinement of the measures using larger sample sizes and in other academic contexts is needed. In addition, qualitative exploration regarding students' perceptions of 3D/virtual technology self-efficacy is needed.

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References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (2006). Guide to constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307–337). Greenwich, CT: Information Age.

Baytar, F. (2018). Apparel CAD patternmaking with 3D simulations: Impact of recurrent use of virtual prototypes on students' skill development. *International Journal of Fashion Design, Technology and Education, 11*(2), 187-195. doi: 10.1080/17543266.2017.1378731

Blomquist, T., Farashah, A. D., & Thomas, J. (2016). Project management self-efficacy as a predictor of project performance: Constructing and validating a domain-specific scale. *International Journal of Project Management, 34*(8), 1417-1432.

Chang, Y. S., Chen, M. Y. C., Chuang, M. J., & Chou, C. H. (2019). Improving creative self-efficacy and performance through computer-aided design application. *Thinking Skills and Creativity, 31*, 103-111.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109-132.

Gu, X., Zhu, Y., & Guo, X. (2013). Meeting the 'digital natives:" Understanding the acceptance of technology in classrooms. *Education Technology & Society, 16*(1), 392-402.

Hodges, N., Watchravesrinkgan, K., Min, S., Lee, Y., & Seo, S. (2020). Teaching virtual technology through industry collaboration: An assessment of pedagogical process and outcomes. *International Journal of Fashion Design, Technology and Education, 13*(2), 120-130.

Laver, K., George, S., Ratcliffe, J., & Crotty, M. (2012). Measuring technology self-efficacy: reliability and construct validity of a modified computer self-efficacy scale in a clinical rehabilitation setting. *Disability and Rehabilitation, 34*(3), 220-227.

McClough, A. C., & Rogelberg, S. G. (2003), Selection in teams: An exploration of the teamwork knowledge, skills, and ability test. *International Journal of Selection and Assessment, 11*(1), 56 – 66.

Park, J., Kim, D. E., & Sohn, M. (2011). 3D simulation technology as an effective instructional tool for enhancing spatial visualization skills in apparel design. *International Journal of Technology and Design Education*, *21*(4), 505-517. doi: 10.1007/s10798-010-9127-3

Riggs, M. L., Warka, J., Babasa, B., Betancourtm R., & Hooker, S. (1994). Development and validation of self-efficacy and outcome expectancy scales for job-related applications. *Evaluation and Psychological Assessment, 54*(3), 793 – 802.

Tatar, N., Yıldız, E., Akpınar, E., & Ergin, Ö. (2009). A study on developing a self-efficacy scale towards science and technology. *Eurasian Journal of Educational Research, 36*(36), 263-280.

Van Dinther, M., Dochy, F., & Segers, M. (2011). Factors affecting students' self-efficacy in higher education. *Educational Research Review, 6*(2), 95-108.

Wiebe, E., Unfried, A., & Faber, M. (2018). The relationship of STEM attitudes and career interest. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(10), em1580.