Rethinking TPACK in the Digital Age: Non-Linear Relationships Between Learning by Design, Teachers' Technology-Related Knowledge and Technology Integration in the Classroom

Joan Bruner-Timmons, Walden University, joan.bruner-timmons@waldenu.edu
Nicolae Nistor, Ludwig-Maximilians-Universität München; Walden University, nic.nistor@uni-muenchen.de
Ionuț Dorin Stanciu, Technical University of Cluj-Napoca, Romania; Walden University, ionut.stanciu@dppd.utcluj.ro

Abstract: Teachers are increasingly required to integrate educational technology in the classroom, therefore to acquire and practically apply technology-related knowledge. This knowledge was described by the TPACK (Technological, Pedagogical and Content Knowledge) framework, and it is assumed to be best acquired by teachers' participation in Learning by Design (LbD) practice. However, little is known about the relationships between LbD, TPACK and technology integration (TI) in the classroom. A survey involving $N = 101$ US American secondary school mathematics teachers was conducted in a northeastern state to address this research gap and, surprisingly, it revealed non-linear relationships. These suggest that, while TPACK partially mediates the LbD-TI relationship as expected, technological knowledge can have a saturation effect on TI, and both LbD and TPACK can, under certain circumstances, decrease TI. Consequences for further research and teacher professional development practice are discussed.

Introduction

Little is currently known about which knowledge and competences may enable teachers to integrate technology in the classroom in a meaningful and effective way, and how teachers can acquire the needed knowledge. One of the few approaches on teachers' technology competences is the Technological, Pedagogical and Content Knowledge (TPACK) framework established by Mishra and Koehler (2006), who further propose the Learning by Design (LbD) approach (Kolodner et al., 2003) carried out in teachers' communities of practice as a means to acquire the necessary TPACK. However, little is known about the relationships between LbD, TPACK, and technology integration (TI) in the classroom. After a brief overview on TPACK and LbD, the paper presents a study addressing this research gap. The findings imply consequences for further research and for teacher professional development, as discussed in the final part.

Research questions and methodology

Aiming to address the research gap identified above, the following research questions were examined. RQ1: To what extent does teacher participation in Learning by Design predict their TPACK? RQ2: To what extent does teacher TPACK predict technology integration? RQ3: To what extent does TPACK mediate the relationship between participation in Learning by Design and technology integration?

A quantitative, correlative field study was employed using cross-sectional questionnaire survey data. The examined population ($N = 101$) was located in a northeastern US American school district with a total of 2862 teachers, from which 127 were teachers of mathematics. The TPACK and LbD variables were measured using the adapted TPACK questionnaire by Zelkowski et al. (2013); additional items were formulated ad-hoc for TPACK and TI. Besides IBM SPSS Statistics 24, data were analyzed using WarpPLS 6.

Findings

In response to **RQ1** (Figure 1 a, b), two nearly linear and positive relationships were found, LbD–TK ($\beta = .42$, $p < .01$, $R^2 = .18$) and LbD–TPACK2 ($\beta = .38$, $p < .01$, $R^2 = .14$). The relationships LbD–TPK ($\beta = -.26$, $p < .01$, $R^2 = .07$), LbD–TCK ($\beta = -.21$, $p < .01$, $R^2 = .04$) and LbD–TPACK ($\beta = .26$, $p < .01$, $R^2 = .07$) were significant in the sense that a curve describing the relationship could be fitted to the data, however the relationship explained a small amount of variance in the dependent variable ($R^2 < .10$). Therefore, these relationships were disregarded. In response to **RQ2**, four strongly curvilinear relationships were found (Figure 1 c, d, e, f): TK-TI ($\beta = .23$, $p < .01$, $R^2 = .18$), TPK-TI ($\beta = .28$, $p < .01$, $R^2 = .20$), TCK-TI ($\beta = .19$, $p < .01$, $R^2 = .16$), and TPACK2-TI ($\beta = -.24$, $p < .01$, $R^2 = .18$). The relationships TPACK–TI and TPACK1–TI were not significant

(p > .05). The mediation analyses responding to **RQ3** indicated both direct and mediated, significant relationships between LbD and TI, with R^2 between .16 and .20. The relationship LbD–TI was U-shaped, with minimum points corresponding to z values of LbD between .25 and .45, as shown in Figure 1 g, h. The mediation by TPK and TCK was disregarded due to the small amount of mediator variance involved ($R^2 < .10$).

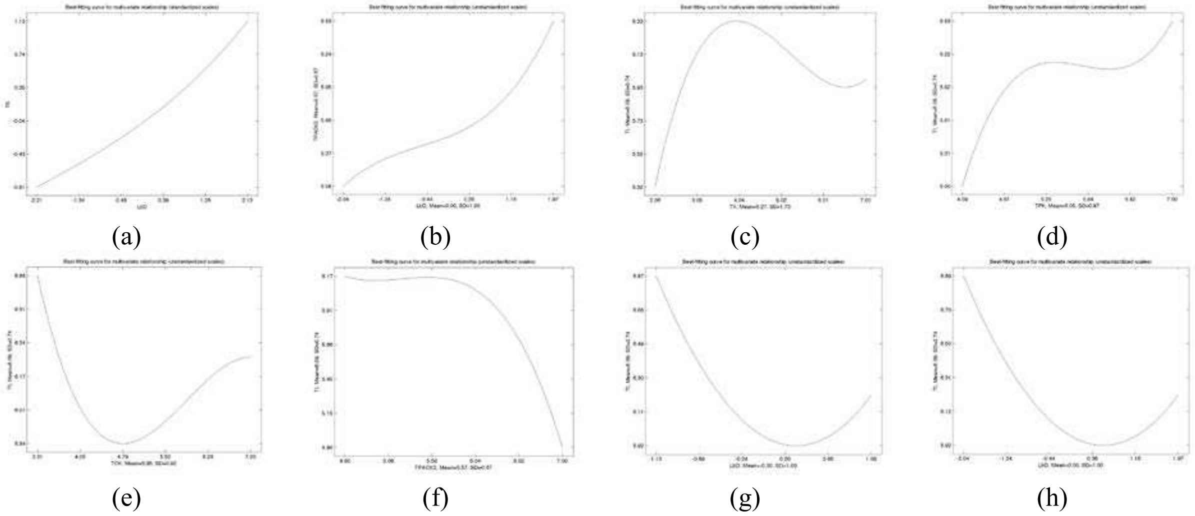

Figure 1. Relationships corresponding to RQ1: (a) LbD–TK, (b) LbD–TPACK2; RQ2: (c) TK–TI, (d) TPK–TI, (e) TCK–TI, (f) TPACK2–TI; RQ3: (g) LbD-TK-TI, and (h) LbD-TPACK2-TI.

Discussion

In general, LbD predicted TI, as suggested by Mishra and Koehler (2004), however according to a U-shaped relationship. This relationship was partially mediated by TK and TPACK2 (specific, applicative technology-related knowledge). More in detail, LbD predicted TK and TPACK2 displaying a nearly linear relationship; and TK, TPK, TCK, and TPACK2 were significant, curvilinear predictors of TI. Interestingly, TPACK1 (general technology-related knowledge) did not predict TI. The surprising results mainly consisted of the curvilinear shaped relationships found between the variables. This suggests that, in the teaching practice, TI may be initially, or partially, based on spontaneous action, rather than on well-founded knowledge. Further unexpected results were the non-linear relationships TK–TI and TPACK2–TI. The relationship TK–TI (Figure 1c) suggests a saturation effect, in the sense that an increase in teachers' knowledge of educational technology may be useful for technology integration only up to a certain limit, after which additional technology applications are hardly possible. Similar findings were reported by Valtonen et al. (2017).

The validity and applicability of the presented findings are limited by several methodological aspects. The findings are based on self-report data, whereas several authors (e.g., Valtonen et al., 2017) criticize the construct validity of the TPACK instrument. The presented results support this point of critique and emphasize the need for a more thorough construct validation, and for the complementary use of more objective data. Furthermore, some authors regard non-linear relationships as a euphemism for non-significant relationships. However, in this study we have made a distinction between both. Lastly, only mathematics teachers were examined, and the study does not include an insight in teachers' specific LbD activities.

References

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., & Ryan, M. (2003) Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting Learning by Design™ into practice. *Journal of the Learning Sciences, 12*(4), 495-547.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record, 108*(6), 1017–1054.

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology, 33*(3). Retrieved from https://www.learntechlib.org/p/180264

Zelkowski, J., Gleason, J., Cox, D., & Bismarck, S. (2013). Developing and validating a reliable TPACK instrument for secondary mathematics preservice teachers. *Journal of Research on Technology in Education, 46*(2), 173–206.

