SELF-EFFICACY, PEDAGOGICAL BELIEFS, AND ATTITUDES TOWARD TECHNOLOGY: A CLASSICAL MEDIATION ANALYSIS AMONG PRE-SERVICE SCIENCE TEACHERS

Lowell M. Gabunilas[1*]
University of Science and Technology of Southern Philippines
*For Correspondence, email: lowell.gabunilas@ustp.edu.ph

ABSTRACT: *A teacher's attitude toward technology is one of the strongest determinants of classroom technology integration, shaped by underlying beliefs such as teaching self-efficacy and pedagogical beliefs about instruction. This study examined the relationship of pre-service science teachers' teaching self-efficacy and teaching beliefs to attitude toward technology, and tested whether either construct mediates the other's effect on attitude toward technology. Ninety-eight pre-service science teachers completed the STEBI-B, BASSSQ, and ATT questionnaires; multiple regression and mediation analysis were conducted after verifying assumptions. Teaching beliefs significantly predicted attitude toward technology and fully mediated self-efficacy's effect on attitude, whereas self-efficacy did not mediate teaching beliefs' effect on attitude toward technology. Self-efficacy appears to influence technology attitudes indirectly through pedagogical beliefs. Teacher education programs must prioritize cultivating constructivist beliefs, not self-efficacy alone, to promote integration of technology.*

Keywords: *teaching self-efficacy, pedagogical beliefs, attitude toward technology, mediation analysis, pre-service science teachers*

I. INTRODUCTION

Recognizing the vital role that technology plays in advancing science education, teacher education programs now emphasize training pre-service teachers in technology integration. While the actual utilization of technology in the teaching and learning process has been a major focus of global research, educational insights reveal that once technical access and basic knowledge are secured, intrinsic factors play the deciding role in successful technology integration [1]. Among these intrinsic factors, a teacher's attitude toward technology is consistently identified as the strongest and most immediate determinant of actual classroom implementation [2-4]. For any technology-driven educational initiative to succeed, the participating educators must harbor positive attitudes toward its use [5]. Regardless of the availability, capacity, or sophistication of the infrastructure, it is the teacher's underlying attitude that ultimately dictates the depth of its implementation in the classroom [6, 7]. These attitudes do not form in a vacuum; they are grounded in teachers' core beliefs about their profession and the nature of teaching and learning, which provide the cognitive foundation for their professional mindsets [8]. Indeed, teachers' belief systems play a pivotal role in shaping their receptivity toward educational innovations.

A prominent teacher belief within this cognitive framework is teaching self-efficacy, defined as a teacher's belief in their own capability to achieve specific instructional objectives [9]. In the context of science education, teaching self-efficacy specifically reflects an educator's confidence in their ability to facilitate student learning of complex scientific concepts. High teaching self-efficacy is a critical predictor of overall instructional effectiveness, student academic achievement, and progressive classroom practices [10]; furthermore, it has proven to be a robust predictor of positive attitudes toward technology utilization in teaching [11]. Empirical evidence underscores the connection between teaching self-efficacy and the integration of technology tools to facilitate learning. Early foundational research by Enochs, Riggs, and Ellis [12] regarding teacher self-efficacy demonstrated that an educator's confidence in their ability to facilitate science learning is a baseline prerequisite for promoting technology integration in the classroom. When teachers experience greater professional autonomy to utilize their skills, they tend to exhibit significantly more positive attitudes toward instructional technology [13]. Driven by a strong sense of professional capability and commitment to their students, highly efficacious teachers actively seek out modern pedagogical innovations and become avid users of technology to support student learning [14]. Teachers' self-efficacy levels are significantly related to their classroom practices, including technology implementation, noting that highly efficacious educators excel at differentiating instruction to meet diverse learner needs [15]. However, the precise relationship between self-efficacy and the nature of technology application remains nuanced. Research revealed that while teaching self-efficacy directly relates to generalized technology use, it exerts minimal influence on whether a teacher adopts a traditional or a constructivist approach to that technology [16]. While the link between teaching self-efficacy and technology integration is well-supported by correlational data, these studies often stop short of explaining the underlying mechanisms that dictate *how* and *why* specific instructional styles are chosen.

Beyond self-efficacy, teachers hold distinct pedagogical beliefs or teaching beliefs regarding the nature of knowledge and how it should be processed. Science teachers, in particular, maintain deeply ingrained beliefs about science instruction and their methodological approaches [17-19], which heavily dictate how they navigate educational innovations. Despite science transcending cultural and linguistic boundaries, research indicates that teachers worldwide exhibit highly diverse beliefs regarding the nature of science and how it should be taught which influences how they present the subject matter to their students [19]. This variation in instruction is heavily driven by a teacher's underlying pedagogical philosophy. Teaching beliefs are inextricably linked to epistemological views of science and the philosophical foundations of education. Teachers who embrace constructivist beliefs naturally design student-centered lessons that leverage modern educational tools, operating under the conviction that technology makes learning more meaningful by helping students actively construct their own knowledge [20]. Consequently, constructivist teachers are significantly more likely to utilize modern technological solutions to bridge learning gaps in the classroom [21]. Rather than using digital tools for passive information delivery, these educators believe that technology should empower students which grants them the autonomy to control information, explore complex concepts, and directly manipulate data. Interestingly, several findings suggest a complex interplay between teaching self-efficacy and broader teaching beliefs [22-24]. Pre-service teachers who are highly confident in their teaching abilities lean strongly toward constructivist beliefs [23]. This alignment likely occurs because newer generations of educators are trained under prevailing constructivist paradigms which leads them to disassociate effective teaching from traditional, teacher-centered methods. Similarly, teachers who hold their instructional capabilities in high regard are far more likely to adopt constructivist frameworks and maintain a student-centered approach to education [23]. While the independent relationships between self-efficacy, teaching beliefs, and attitudes toward technology are well-documented, a gap remains in understanding the underlying mechanism that connects these three constructs simultaneously. This justifies a multivariate analysis of pre-service teachers' self-efficacy and teaching beliefs in relation to their attitudes toward technology, because the results of this analysis can provide empirical data for science teacher training in higher education This investigation particularly holds significance in the contemporary educational landscape.

This study aimed to examine the relationships among pre-service science teachers' teaching self-efficacy, teaching beliefs, and attitudes toward using technology in teaching and learning. Furthermore, this study also evaluated whether teaching beliefs mediate the effect of self-efficacy on technology attitudes, or conversely, whether teaching self-efficacy mediates the relationship between teaching beliefs and technology attitudes.

II. METHODOLOGY

Research Design

This study utilized a non-experimental cross-sectional explanatory design [25].

Instruments

Three questionnaires were utilized in this study. The STEBI-B was used to measure the science teaching self-efficacy of the pre-service teachers [26]. The BASSSQ was used to measure teaching beliefs related to constructivist (post-modernist) and traditional approaches (objectivist) to teaching and learning science [19]. The ATT was used to measure the pre-service teachers' attitude toward using technology in teaching and learning [27].

Respondents and Data Gathering Procedure

Junior and senior level pre-service science teachers from a state university in Northern Mindanao, Philippines, who had completed most of their pre-internship major courses, were invited to participate in a survey. Because this study is nested within a larger project, the sample was drawn from a single institution. The survey was voluntary and no personal data were collected from the respondents. Descriptive analysis and pre-regression assumption checks were conducted prior to the main multivariate regression analysis of gathered data.

III. RESULTS AND DISCUSSION

All three instruments use a 5-point response format, and none of the original source publications specify fixed numeric cutoffs for classifying respondents' scores. Descriptive interpretation is therefore anchored to each scale's neutral midpoint which is a mean item score of 3.0 with mean item scores above 3.0 indicating a tendency toward the favorable pole of the construct and scores at or below 3.0 indicating a tendency toward the opposite pole.

Science Teaching Self-Efficacy

As shown in Table 1, respondents reported a relatively high overall level of science teaching self-efficacy (M = 89.33, SD = 7.14). All respondents scored above the scale midpoint. The Personal Science Teaching Efficacy subscale was notably higher than the Science Teaching Outcome Expectancy subscale which indicates that respondents were more confident in their own capability to teach science effectively than in their belief that good teaching reliably overcomes external barriers to student achievement. This pattern is consistent with prior applications of the STEBI-B, in which the STOE subscale has repeatedly proven more difficult for pre-service teachers to positively endorse than the PSTE subscale [26].

Table 1: Descriptive Statistics for the STEBI-B and Its Subscales (N = 98)

Scale	M	SD	Min	Max	% > midpoint
STOE	37.11	3.92	23	50	95.9
PSTE	52.21	5.43	33	65	99.0
STEBI-B	89.33	7.14	70	115	100.0

Note. % > midpoint = percentage of respondents scoring above the scale's neutral midpoint of 3 per item.

Teaching Beliefs

As shown in Table 2, respondents' overall teaching beliefs leaned toward the postmodern/constructivist end of the BASSSQ continuum, with 96.9% scoring above the midpoint. However, it was not uniform across subscales. Beliefs about school science specifically were the most strongly constructivist: the Certainty of Scientific Knowledge subscale for school science (TVSE-CSSK) and its Process of Scientific Inquiry counterpart (TVSE-PSSI) were both endorsed well above the midpoint by nearly all respondents (96.9% and 99.0%, respectively). Beliefs about the nature of science itself were comparatively more traditional and more evenly divided among respondents. The Process of Scientific Inquiry subscale for science (TVS-PSI) showed a more moderate lean, and the Certainty of Scientific Knowledge subscale for science (TVS-CSK) sat almost exactly at the scale midpoint, with only 46.9% of respondents scoring above it. This suggests that while respondents were fairly consistent in preferring inquiry-based, student-centered approaches for teaching school science, they were considerably more divided in their epistemological views of whether scientific knowledge itself is certain and objective or tentative and context-dependent, a distinction Aldridge *et a*l. [19] noted can be conceptually difficult for practicing science teachers to disentangle from their views of school science specifically.

Table 2. Descriptive Statistics for the BASSSQ and Its Subscales (N = 98)

Scale	M	SD	Min	Max	% > midpoint
TVS-PSI	33.37	3.77	24	45	78.6
TVS-CSK	30.32	4.16	17	46	46.9
TVSE-PSSI	42.18	3.05	30	51	99.0
TVSE-CSSK	37.18	4.35	27	45	96.9
BASSSQ	143.05	11.88	107	187	96.9

Note. Higher scores indicate a more postmodern/constructivist view; lower scores indicate a more objectivist/traditional view.

Attitude Toward Technology

As shown in Table 3, respondents reported a strongly positive overall attitude toward technology, the highest mean item score of the three constructs measured, with all 98 respondents (100%) scoring above the midpoint. It is also worth noting that the overwhelming majority of respondents rejected anti-technology statements outright, while a small number of respondents scored distinctly lower, indicating a small subgroup with more traditional or technology-averse views embedded within an otherwise strongly pro-technology sample.

Table 3. Descriptive Statistics for the ATT (N = 98)

Scale	M	SD	Min	Max	% > midpoint
ATT	83.10	6.03	68	95	100.0

Test of Normality, Multicollinearity, and Homoscedasticity

The predictor variables were science teaching self-efficacy (STEBI-B) and teaching beliefs (BASSSQ), and the outcome variable was attitude toward technology (ATT). Prior to conducting the multiple regression and mediation analyses, the data were screened for violations of the statistical assumptions. Normality was evaluated using the Shapiro-Wilk test and the result was not statistically significant, W(98) = .99, p = .446, indicating no evidence of departure from normality. In the multicollinearity test, the two predictor variables returned a variance inflation factor (VIF) of 1.04 and a tolerance of .96, and the bivariate correlation between STEBI-B and BASSSQ was r = .21 which satisfy the multicollinearity test. Homoscedasticity of the residuals was tested using both the Breusch-Pagan test and the White test. Neither test was statistically significant: Breusch-Pagan, LM(2) = 3.70, p = .157; White, LM(5) = 7.64, p = .177. The assumption of homoscedasticity is fully met.

Relationship Between Self-Efficacy, Teaching Beliefs and Attitude Toward Technology, and Mediation Analysis

To determine the relationship among the variables, the classical Baron and Kenny [28] method of mediation analysis was used which provides a larger picture in the examination of the relationships among the variables as this method incorporates univariate regressions and multivariate regressions in its procedure. To examine whether one predictor mediated the relationship between the other predictor and ATT, The procedure requires (a) the independent variable (X) to significantly predict the outcome (Y), establishing the total effect, c; (b) X to significantly predict the mediator (M), path a; (c) M to significantly predict Y when controlling for X, path b; and (d) comparison of the direct effect of X on Y controlling for M, path c′, against the original total effect c. This method is highly appropriate here because the data meets assumptions and involves a simple, straightforward chain where one variable explains the link between the other two.

The total effect of STEBI-B on ATT was statistically significant, B = 0.20, SE = 0.08, t(96) = 2.40, p = .019 (Step 1). STEBI-B significantly predicted BASSSQ, B = 0.34, SE = 0.17, t(96) = 2.06, p = .042 (Step 2). With both STEBI-B and BASSSQ entered as predictors of ATT, BASSSQ remained a significant predictor, B = 0.18, SE = 0.05, t(95) = 3.85, p < .001 (Step 3, path b), while the direct effect of STEBI-B on ATT was reduced and no longer statistically significant, B = 0.14, SE = 0.08, t(95) = 1.72, p = .090 (Step 4, path c′). This drastic decrease in the significance of STEBI-B indicates a full mediation of BASSSQ. This reveals that BASSSQ mediates STEBI-B and ATT. This result also shows that STEBI-B does not mediate BASSSQ and ATT. Table 4 summarizes the four steps, and Figure 1 presents the corresponding path diagram.

Table 4: Baron and Kenny Steps, STEBI-B → BASSSQ → ATT

Step	Path	Regression	B	SE	t	p
1	c	ATT ~ STEBI-B	0.20	0.08	2.40	.019
2	a	BASSSQ ~ STEBI-B	0.34	0.17	2.06	.042
3	b	ATT ~ STEBI-B + BASSSQ (BASSSQ)	0.18	0.05	3.85	< .001
4	c′	ATT ~ STEBI-B + BASSSQ (STEBI-B)	0.14	0.08	1.72	.090

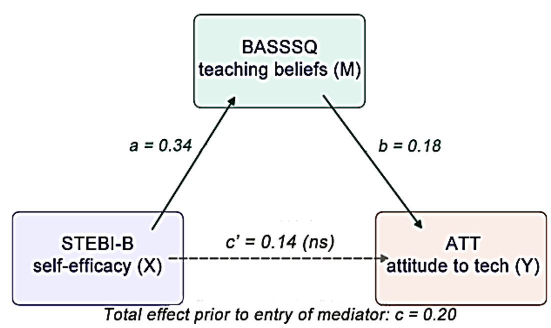

Figure 1. Path Diagram (STEBI-B → BASSSQ → ATT)
Note. Dashed lines indicate a nonsignificant path.

By showing that the statistical influence runs from self-efficacy through teaching beliefs to attitude toward technology, this study clarifies the mechanism connecting three well-studied constructs and offers an empirically grounded account of where in the sequence of a teacher's belief development an intervention targeting technology attitudes would need to act.

For curriculum designers, the clearest implication of these results is that experiences intended to cultivate positive attitudes toward technology are unlikely to succeed if they target teaching self-efficacy alone. Teaching confidence-building activities remain valuable because self-efficacy was shown here to contribute to constructivist beliefs. However, because it is teaching beliefs, and not self-efficacy directly, that carry this influence through to attitude toward technology, curriculum designers should treat belief change, especially the shift toward constructivist views of science teaching and learning, as a distinct and necessary curriculum target in its own right. Course components that explicitly model constructivist, student-centered uses of technology, rather than technical training alone, appear better aligned with the pathway identified in this study.

For teacher mentors working directly with pre-service teachers, since self-efficacy predicted constructivist beliefs in this sample, mentors can continue to build efficacy through structured mastery experiences, but coaching should not stop there. Mentors and cooperating teachers could explicitly connect mastery experiences to constructivist principles during post-lesson reflection, for instance, by asking pre-service teachers to articulate how a successful lesson shifted their view of the student's role in learning, rather than only how it shifted their confidence. Pre-service teachers may also be paired with cooperating teachers who model constructivist, technology-integrated practice, since it is this belief system that the present study identifies as the more direct determinant of positive attitudes toward technology.

This study is preliminary in nature with clear limitations. The non-experimental, cross-sectional, explanatory design means that the mediation identified here describes a statistical pattern, not a demonstrated causal process. The sample size, while adequate for the regression models estimated, is modest for mediation analysis and should be replicated in a larger sample. Finally, all three constructs were measured through self-report questionnaires completed at a single sitting, which raises the possibility of common method variance inflating the observed associations among the scores.

IV. CONCLUSION

In this study, teaching beliefs emerged as the more proximal predictor: self-efficacy's association with attitude toward technology was fully mediated by teaching beliefs, while teaching beliefs retained a significant direct effect on attitude independent of self-efficacy. These findings suggest that confidence in one's teaching ability shapes attitudes toward technology primarily by shaping broader pedagogical beliefs, rather than through a direct pathway of its own. For teacher education programs, this indicates that cultivating constructivist teaching beliefs, not simply building self-efficacy, is the more direct route to fostering positive attitudes toward technology among pre-service science teachers. Because the design was cross-sectional, longitudinal or experimental research is needed to confirm the directionality this mediation model assumes.

V. REFERENCES

[1] C. M. Kim, M. K. Kim, C. J. Lee, J. M. Spector, and K. DeMeester, "Teacher beliefs and technology integration," *Teach. Teach. Educ.*, vol. 29, no. 1, pp. 76–85, 2013, doi: 10.1016/j.tate.2012.08.005.

[2] F. D. Davis, "A technology acceptance model for empirically testing new end-user information systems: Theory and results," Massachusetts Institute of Technology, 1985. doi: 10.1126/science.146.3652.1648.

[3] B. Eickelmann and M. Vennemann, "Teachers' attitudes and beliefs regarding ICT in teaching and learning in European countries," in *European Educational Research Journal*, 2017, pp. 733–761. doi: 10.1177/1474904117725899.

[4] G. Sang, M. Valcke, J. van Braak, and J. Tondeur, "Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology," *Comput. Educ.*, vol. 54, no. 1, pp. 103–112, 2010, doi: 10.1016/j.compedu.2009.07.010.

[5] T. Teo, C. B. Lee, and C. S. Chai, "Understanding pre-service teachers' computer attitudes: Applying and extending the technology acceptance model," *J. Comput. Assist. Learn.*, vol. 24, no. 2, pp. 128–143, 2008, doi: 10.1111/j.1365-2729.2007.00247.x.

[6] Y. M. Huang, "Exploring the factors that affect the intention to use collaborative technologies: The differing perspectives of sequential/global learners," *Australas. J. Educ. Technol.*, vol. 31, no. 3, pp. 278–292, 2015, doi: 10.14742/ajet.1868.

[7] T. Teo, F. Huang, and C. K. W. Hoi, "Explicating the influences that explain intention to use technology among English teachers in China," *Interact. Learn. Environ.*, vol. 26, no. 4, pp. 460–475, 2018, doi: 10.1080/10494820.2017.1341940.

[8] T. K. F. Chiu and D. Churchill, "Adoption of mobile devices in teaching: changes in teacher beliefs, attitudes and anxiety," *Interact. Learn. Environ.*, vol. 24, no. 2, pp. 317–327, 2016, doi: 10.1080/10494820.2015.1113709.

[9] A. Bandura, "Self-efficacy: toward a unifying theory of behavioral change," *Psychol. Rev.*, vol. 84, no. 2, pp. 191–215, 1977.

[10] D. Barni, F. Danioni, and P. Benevene, "Teachers' self-efficacy: The role of personal values and motivations for teaching," *Front. Psychol.*, vol. 10, no. JULY, pp. 1–7, 2019, doi: 10.3389/fpsyg.2019.01645.

[11] E. J. Rohaan, R. Taconis, and W. M. G. Jochems, "Analysing teacher knowledge for technology education in primary schools," *Int. J. Technol. Des. Educ.*, vol. 22, no. 3, pp. 271–280, 2012, doi: 10.1007/s10798-010-9147-z.

[12] L. G. Enochs, I. M. Riggs, and J. D. Ellis, "The development and partial validation of microcomputer utilization in teaching efficacy beliefs instrument in a science setting," *Sch. Sci. Math.*, vol. 93, no. 5, pp. 257–263, 1993, doi: 10.1111/j.1949-8594.1993.tb12240.x.

[13] H. Serin and F. Bozdağ, "Relationship between teachers' attitudes towards technology use in education and autonomy behaviors," *TOJET Turkish Online J. Educ. Technol.*, vol. 19, no. 3, pp. 60–69, 2020, [Online].

Available: https://files.eric.ed.gov/fulltext/EJ1261402.pdf

[14] G. Alibakhshi, F. Nikdel, and A. Labbafi, "Exploring the consequences of teachers' self-efficacy: a case of teachers of English as a foreign language," *Asian-Pacific J. Second Foreign Lang. Educ.*, vol. 5, no. 1, pp. 1–19, 2020, doi: 10.1186/s40862-020-00102-1.

[15] S. K. Khanshan and M. H. Yousefi, "The relationship between self-efficacy and instructional practice of in-service soft disciplines, hard disciplines and EFL teachers," *Asian-Pacific J. Second Foreign Lang. Educ.*, vol. 5, no. 1, pp. 1–20, 2020, doi: 10.1186/s40862-020-0080-8.

[16] T. Teo, "Examining the relationship between student teachers' self-efficacy beliefs and their intended uses of technology for teaching: A structural equation modelling approach," *Turkish Online J. Educ. Technol. - TOJET*, vol. 8, no. 4, pp. 7–15, 2009, [Online]. Available: http://search.proquest.com/openview/61926e0097cc187306a4cb5dfe8143de/1?pq-origsite=gscholar

[17] A. P. Gilakjani and N. B. Sabouri, "Teachers' beliefs in english language teaching and learning: A review of the literature," *English Lang. Teach.*, vol. 10, no. 4, p. 78, 2017, doi: 10.5539/elt.v10n4p78.

[18] C. M. Norris, J. E. Morris, and G. W. Lummis, "Preservice teachers ' self-efficacy to teach primary science based on ' science learner ' typology based on ' science learner ' typology," *Int. J. Sci. Educ.*, vol. 40, no. 18, pp. 2292–2308, 2018, doi: 10.1080/09500693.2018.1528645.

[19] J. Aldridge, P. Taylor, and C. Chen, "Development, validation and use of the beliefs about science and school science questionnaire (BASSSQ)," *Natl. Assoc. Res. Sci. Teach.*, pp. 1–15, 1997.

[20] T. Teo, C. S. Chai, D. Hung, and C. B. Lee, "Beliefs about teaching and uses of technology among pre-service teachers," *Asia-Pacific J. Teach. Educ.*, vol. 36, no. 2, pp. 163–174, 2008, doi: 10.1080/13598660801971641.

[21] A. Pourhosein Gilakjani, L. Mei Leong, and H. Nizam Ismail, "Teachers' Use of Technology and Constructivism," *Int. J. Mod. Educ. Comput. Sci.*, vol. 5, no. 4, pp. 49–63, 2013, doi: 10.5815/ijmecs.2013.04.07.

[22] M. Cansiz and N. Cansiz, "How do sources of self-efficacy predict preservice teachers' beliefs related to constructivist and traditional approaches to teaching and learning?," *SAGE Open*, vol. 9, no. 4, 2019, doi: 10.1177/2158244019885125.

[23] O. Gürbüztürk and S. N. Şad, "Student teachers' beliefs about teaching and their sense of self-efficacy : A descriptive and comparative analysis," *Inonu Univ. J. Fac. Educ.*, vol. 10, no. 3, pp. 201–226, 2009.

[24] Y. Nie, G. H. Tan, A. K. Liau, S. Lau, and B. L. Chua, "The roles of teacher efficacy in instructional innovation: its predictive relations to constructivist and didactic instruction," *Educ. Res. Policy Pract.*, vol. 12, no. 1, pp. 67–77, 2013, doi: 10.1007/s10671-012-9128-y.

[25] B. Johnson, "Toward a New Classification of Nonexperimental Quantitative Research," *Educ. Res.*, vol. 30, no. 2, pp. 3–13, 2001, doi: 10.3102/0013189X030002003.

[26] E. V. Slater, C. M. Norris, and J. E. Morris, "The validity of the science teacher efficacy belief instrument (STEBI-B) for postgraduate, pre-service, primary teachers," *Heliyon*, vol. 7, no. 9, p. e07882, 2021, doi: 10.1016/j.heliyon.2021.e07882.

[27] S. Yavuz, "Developing a technology attitude scale for pre-service chemistry teachers," *Turkish Online J. Educ. Technol.*, vol. 4, no. 1, pp. 17–25, 2005.

[28] R. M. Baron and D. A. Kenny, "The moderator-mediator variable distinction insocial psychological research. conceptual, strategic, and statistical considerations," *J. Pers. Soc. Psychol.*, vol. 51, no. 6, pp. 1173–1182, 1986, doi: 10.1037/0022-3514.51.6.1173.