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An Analysis of Factors Affecting Students' Use of Interactive Learning Tools in Engineering Education

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1. Introduction

In this age of ever-evolving technology, teachers are finding more advanced ways to help students connect with course content. The process of learning has become increasingly interactive to meet current students' expectations. According to a recent study, students are tethered to digital technology [1]. Therefore, digital technology is now essential for them to construct and manage their lives. For this reason, this generation has different expectations regarding how they learn and how they want to be taught.

A hallmark of digital technology might be interactivity. Interactivity can be achieved through diverse experiences, including two-way or reciprocal communication [2-4], tailored content (i.e., customization or personalization) [5-6], and synchronous interaction with a system [2]. Interactivity is viewed as residing in the medium or technological feature itself. It suggests and permits interaction [7-8]. Therefore, the very presence of interactive features can constitute diverse interactivity features that are readily available in digital technology. For example, websites nowadays offers personalization, customization, live chatting, zoom-and-out function and so on. Such features allow users to interact with the system. Interactive learning tools (ILTs) also offer diverse interactivity features such as interactive textbooks, interactive quizzes, and highlighting functions. Therefore, the interactivity afforded by ILTs might help satisfy students' expectations and optimize communication.

Given the interactive features of ILTs, students can receive just-in-time and greater learner-centered education, which is expected to improve their academic performance. However, students' individual characteristics might alter the effectiveness of ILTs. Student have different levels of interest in using new technology and different levels of mastery of technology based on prior experience, expertise, and efficacy. Such differences lead to varying uses of learning tools that ultimately result in different perceptions on the tools as well as individual academic performance. Thus, this study aims to investigate how individuals' traits associated with technology use contribute to the perceptions of ILTs to better explain what motivates and encourages students to strategically use ILTs.

Among diverse individual characteristics, this study focuses on the effects of students' interest in using new technologies and their levels of expertise in using such technologies on the evaluation of the quality of ILTs. In the context of engineering education, the body of research has focused on introducing developed computing systems or technology, such as virtual laboratories [9-10], e-learning [11], and interactive learning tools [12], as interactive educational tools. However, we know little about how students' individual personal traits leverage the effect of such tools, especially concerning the tools' psychological, attitudinal, and behavioral effects. Thus, this study will fill this gap in the literature in engineering education.

2. Roles of Interactive Learning Tools in Engineering Education

Students usually perform much better when they actively engage in their learning process, evaluate what they are learning, and regulate their own learning path instead of being passive listeners. Active learning is defined in [13] as "any instructional method that engages students in the learning process." The motivation comes from educational experience when students deal with active learning and reflection [14-15]. However, traditional engineering education involves listening to lectures, completing homework, taking exams, and receiving feedback after grading is done. This education model may adversely affect the students' active participation.

The utilization of information and communication technologies in engineering education can allow students to be active learners by letting them control how, when, and where they study depending on their learning needs and styles [16]. Therefore, engineering education can be more effective by incorporating online ILTs into the curriculum without having to feel the burden of flipping a classroom. Among the many available ILTs, this study examines the effects of the tools based on the survey responses from the users of McGraw-Hill's ILTs, such as SmartBook and Connect, that are used for engineering courses in many U.S. universities and colleges.

3. Benefits of Interactive Learning Tools

Students in general, including engineering students, have not demonstrated a keen interest in reading textbooks [17]. Thus, one of the biggest challenges that instructors face is motivating students to read assigned chapters that deliver fundamental concepts, theories, and learning objectives. Interactive online tools, such as interactive textbooks, may motivate students to read assigned materials. For example, students can access interactive online textbooks anytime using their portable mobile devices or tablets, which facilitate convenient and speedy communication and allow a personalized form of active learning at any time and location [18-19]. Each chapter includes hyperlinks to the text most relevant for learning objectives to help students easily grasp and focus on important parts. The interactive features can periodically remind students that they need to review the learning objectives to boost their acquired knowledge before it fades away.

With interactive learning tools (ILTs), instructors have the option to record live lectures, which students can then replay and review at their convenience and in accordance with their own learning pace to take advantage of the actual lectures' narrative visualization. The tools help divide a lecture into several short video segments instead of a typical lecture of 50 minutes or more, since short segments are preferable to maximize the students' concentration [20-21].

ILTs can provide students with instant feedback, not only to enhance their understanding of course materials but also to help students to improve their problem-solving skills. For example, instructors can customize the tools such that students who complete reading assignments get quizzed on their comprehension before and/or after specific topics are discussed in class. The quizzes are graded instantly, meaning that students get immediate feedback on their performance without having to wait until the traditional method of manual grading is done. It is, however, worth noting that this feature limits the types of questions offered.

The Hint and Guided Solution in Connect can provide step-by-step interactions with students as they solve problems. The hyperlinks direct students to relevant areas and specific learning objectives in the online textbook, which encourages them to revisit the fundamentals and to eventually solve the problems on their own. When the students try again, the randomization feature generates similar problems, not the same problems, for them to solve. ILTs also generate self-assessment reports allowing students to quickly assess their learning progress in the course, which gives them the opportunity to focus on these areas in which they need to improve.

In summary, ILTs encourage students to read course materials, test knowledge, give immediate feedback, and monitor progress. Therefore, these tools allow student-centered autonomous learning. Moreover, they make it possible for the student to focus on engineering subjects, thereby achieving the learning objectives.

4. Factors Affecting Evaluations on Interactive Learning Tools

Despite the advantages of interactive learning tools (ILTs), not all students use them effectively, and others may not evaluate them positively. What prompts such different outcomes? This study proposes that individuals' personal characteristics predispose them to evaluate the quality of ILTs. Thus, the central question driving this study is how students' individual characteristics, especially those associated with technologies, influence their evaluations of ILTs. They are technologically innovative and advanced. Thus, individuals' characteristics/personality traits associated technologies may affect how effectively they use technologies.

First, studies have demonstrated that different levels of interest in technology determine varying evaluations of technologies or innovations [22-23]. The characteristic that represents the interest in new technologies and innovation is called "innovativeness," according to Rogers [22]. He developed the model of the diffusion of innovations and describes it as "the degree to which an individual is relatively earlier in adopting an innovation than other members of his system" [24]. Innovativeness is described as a "generalized personality trait" [25], "global personality trait" [26], and as one of a battery of traits that explain "a variety of interpersonal, cognitive, and value orientations likely to have important implications for a person's functioning" [27]. Therefore, simply put, it is a different degree of willingness to try new things.

The concept of innovativeness also has been investigated in the area of engineering education. Ferguson and Ohland [28] explicated this concept as a virtue of engineers. They argued that an engineer's innovativeness is a multidimensional concept that consists of four different aspects: creativity, problem solving, design thinking, and entrepreneurism. Then, such innovativeness determines the innovative potential for an engineer. Menold and his colleagues [29] also developed the definition of engineering innovativeness as a socially constructed concept.

While the concept of innovativeness has been examined in diverse areas including engineering education, the current study uses the definition of Rogers for the effect of innovativeness as a "generalized" personal trait, not limited to certain contexts.

According to previous research [22, 30], innovative individuals are more likely to show interest in learning new innovations. Moreover, it is found in [31] that individuals with personality traits associated with innovativeness are more motivated to use and enjoy stimulating technologies than individuals without such traits. Such "venturesome" or "innovative" characteristics may alter the use of ILTs given that it affects the levels of interest or motivation to use them.

However, for the better use of new technological tools, high levels of interest may not be sufficient. Indeed, one must be equipped with the appropriate knowledge or skills to overcome a new tool's technological complexity [32]. A study that explicates such expertise explains that an individual has a different degree of mastery of technology based on his or her prior experiences, expertise, and efficacy [33]. Individuals with a high level of expertise (i.e., power users) are more likely to use innovative technologies without any difficulties. In contrast, users with a low level of expertise (i.e., non-power users) often show less interest toward newer technology [33]. In previous research [33-35], expertise in using technologies (or power usage) was found to be pivotal in explaining individuals' experiences with technologies. In particular, research shows that power users demonstrate more positive attitudes toward an interactive website than non-power users [34] due to greater engagement with the interface.

These two technology-driven individual characteristics (i.e., innovativeness and expertise) are closely related such that individuals who are more innovative generally show higher mastery of technologies according to Rogers' innovator adopter category [22]. Expertise also refers to a "user's demonstration of evolved technology use" [33]. The more innovative individuals are, the more they adopt and use technologies, such as webcasting and interactive television [30, 36].

Both innovativeness and expertise (or power usage) can affect evaluations of technology. Previous studies [37-38] have demonstrated that individual factors such as personality, skill, experience, and ability are strongly correlated with the evaluation or perception of a product. This is because individuals are able to experience different levels of feelings (either positive or negative) depending on their knowledge, skill, or experience. Such evaluations of ILTs can be dictated by attitudinal and behavioral outcomes. In other words, if individuals have positive perceptions of ILTs, it is likely that they have favorable attitudes toward said tools and greater behavioral intention to use them again in the future. In explaining how the aforementioned individual characteristics (i.e., innovativeness and power usage) play significant roles in increasing positive attitudes and/or behavioral intention, three factors can be considered: (1) perceived ease of use (2) perceived usefulness, and (3) compatibility. Three factors are critical determinants in important theories (i.e., Davis's Technology Acceptance Model and Rogers' Model of Diffusion of Innovations). These models serve as one of the most solid theoretical framework in order to investigate both technology adoption and continuance behavior.

Perceived ease of use and perceived usefulness are important constructs in the technology acceptance model developed by Davis [39]. This model explains how users come to accept and use a technology, suggesting that when users are presented with a new technology, perceived ease of a technology and perceived usefulness determine their decision on its use. Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free from effort" [39]. Thus, perceived ease of use is relevant to the complexity or usability of the system. If the system is easy to use, then users are able to achieve their goal with the system effectively and efficiently [40]. Perceived usefulness refers to "the degree to which a person believes that using a particular system would enhance his or her job performance" [39]. Recognizing advantageous attributes of the system results in perceptions of usefulness.

In considering the relationship between individual characteristics, concerning innovativeness and power usage, and perceived ease of use, if a student has higher levels of motivation, interest, and skills in using ILTs, he or she would use them without difficulty or hesitation. Therefore, individuals with high innovativeness and power usage are more likely to perceive ILTs as easy to use. Higher levels of perceived ease of use, or usability, of a website can make an immersive experience on the interface. This is because if one perceives it as easy to use, he or she is able to control the flow of interactions and information in the interface [35]. Moreover, a student with greater innovativeness and/or power usage can achieve the goal with reasonable efforts and perceive greater usability. On the other hand, if the interface is not considered easy to use, it may cause confusion and disorientation about what needs to be accomplished. Therefore, such confusion or disorientation reduces efficiency and effectiveness [41]. Thus, the following hypotheses are suggested:

H 1: Innovativeness will be positively related to the perceived ease of use of ILTs.
H 2: Power usage will be positively related to the perceived ease of use of ILTs.

Students with innovativeness are more likely to show a willingness to learn and explore technology such as ILTs [30, 32]. Thus, they are more likely to explore diverse technological features, which can eventually introduce them to greater advantageous attributes of the system. Similarly, students with power usage can take advantage of diverse features and thus use ILTs more effectively, especially without difficulties. Therefore, they can easily perceive the usefulness of ILTs. Thus, the following hypotheses are suggested:

H 3: Innovativeness will be positively related to the perceived usefulness of ILTs.
H 4: Power usage will be positively related to the perceived usefulness of ILTs.

Both the perception of ease of use and the perception of usefulness are important determinants of attitudinal and/or behavioral outcomes. According to Davis' Technology Acceptance Model, the perceived usefulness and ease of use impact behavioral intention. Furthermore, it is reasonable that, if students think the ILTs as easy to use and useful, they tend to evaluate them positively. Thus, this study proposes the following hypotheses:

H 5: Perceived ease of use will be positively related to (1) attitude toward ILTs, and (2) behavioral intention to use ILTs.
H 6: Perceived usefulness will be positively related to (1) attitude toward ILTs, and (2) behavioral intention to use ILTs.

In addition, it is pointed out that compatibility of the innovation or technology can influence its evaluation [22]. According to Rogers' Model of Diffusion of Innovations [22], compatibility concerns how easy the technology or innovation is to incorporate into an individual's life. In general, individuals with innovativeness and power usage tend to perceive technologies as worth using in their lives. They actually use innovative technologies for convenience. Therefore, they are more likely to perceive technologies as compatible with their lifestyle. Thus, the following hypotheses are suggested:

H 7: Innovativeness will be positively related to the perceived compatibility of ILTs.
H 8: Power usage will be positively related to the perceived compatibility of ILTs.

Prior studies have shown that compatibility perception is highly associated with adoption and diffusion of innovations (or technology) [22, 42-43]. An individual would evaluate positively if a certain technology was compatible with his or her existing beliefs or value systems. Then, if it is highly consistent with their value system, they are more likely to adopt and use the technology. In contrast, incompatibility could hinder further use of the technology. In case of ILTs, it is possible that a student uses the tools because the instructor of the class uses them, but he or she may not use them further or may not register courses that use similar tools if those tools are not compatible with their beliefs or value systems. Therefore, it is important to ascertain students' perceptions of compatibility in ILTs. Thus, the following hypothesis is suggested:

H 9: Compatibility will be positively related to (1) attitude toward ILTs, and (2) behavioral intention to use ILTs.

Finally, in addition to attitudinal and behavioral outcomes, this study examines whether such positive evaluations of ILTs ultimately improve academic performance. It is noted that, if a student can use ILTs advantageously with favorable attitudes, it is believed that they are more likely to use said tools. Therefore, such effective use eventually affects their academic performance. As such, this study proposes the following hypotheses:

H 10: Perceived ease of use will be positively related to students' performance (i.e., GPA).
H 11: Perceived usefulness will be positively related to students' performance (i.e., GPA).
H 12: Compatibility will be positively related to students' performance (i.e., GPA).

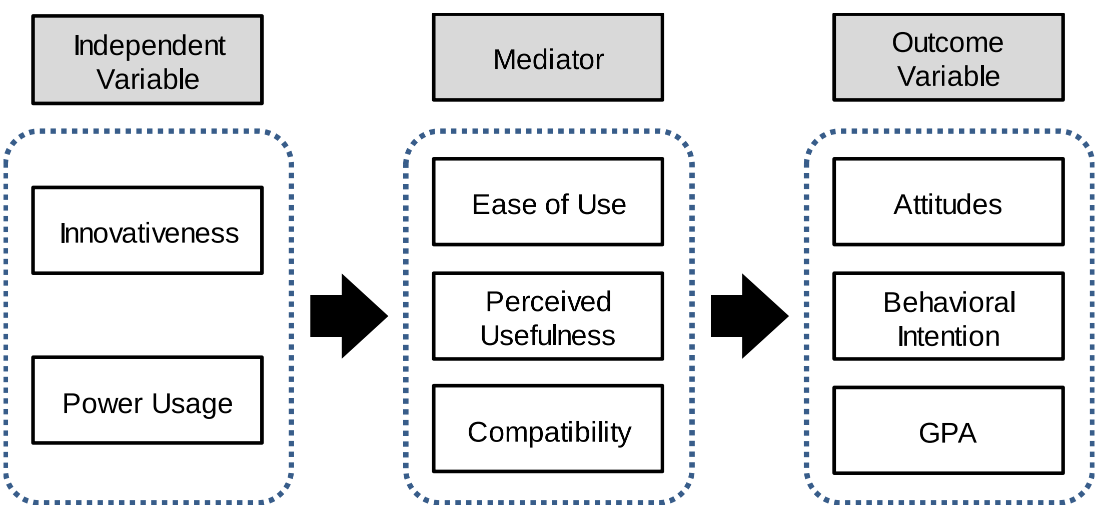

Figure 1. Model of factors affecting evaluation on interactive learning tools (ILTs)

5. Method and Measures

The present study employed an online survey. Participants were recruited from large U.S. universities, ranging from Ivy League to Tier-1 research to Tier-2 public universities that offer traditional four-year undergraduate and/or graduate engineering programs in the fields of CE, EE, and ME. Currently, 259 participants, each of whom uses ILTs for engineering courses, have participated in this study. The descriptive analysis of the demographics showed that 71.4% of the participants were male and 28.2% were female. The majority of the participants were Caucasian (67.6%). The participants range from freshmen to graduate students: 10 freshmen, 42 sophomores, 73 juniors, 69 seniors, 55 graduate students and 10 others (some students indicated that they are non-traditional students, 5th-year seniors, or part-time students) in all three disciplines. The mean (M) age was 26.17 (standard deviation, SD = 6.66). Median age was 25. Although we assume that non-traditional students account for a large number, the major reason why we have such high mean age is due to the large percentage of graduate students (21%). The mean age among graduate students was 28.87 years.

Innovativeness was measured on a 7-point scale adopted from [30] using the following seven statements: (1) I like new challenges; (2) I stay curious; (3) I seek new ideas; (4) I learn new skills; (5) I like to keep up with new innovations; (6) I like to keep up with scientific progress; and (7) I like to keep up with computer technology. (Cronbach's α = 0.90, M = 5.69, SD = 0.95)

Power usage was measured with 12 items obtained from the literature [44] (Cronbach's α = 0.81, M = 5.15, SD = 0.82). All items assessed the degree of mastery of technology based on prior experiences, expertise, and efficacy. For example, the following items are used: "I have to have the latest available upgrades for the technological devices that I use," "I have to have the latest available upgrades for the technological devices that I use," and "I feel like information technology is a part of my daily life."

Perceived usefulness and *perceived ease of use* were measured with TAM scales [39, 45]. The original scales developed by Davis in 1989 consist of 14 items respectively for measuring perceived usefulness and perceived ease of use. Later, he eliminated four items for each variable that were not in line with the others [39]. He further refined ten-item scales to make them more practical to use [39]. Now, six-item scales are predominantly used in relevant studies (e.g., [46-48]) for measuring the two constructs. Specifically, perceived usefulness was measured with five items on 7-point scales. Five items includes: ILTs (e.g., Connect and SmartBook) (1) allowed me to study more effectively; (2) improved my academic performance; (3) increased my productivity; (4) enhanced my effectiveness in learning; (5) was useful for my learning. (Cronbach's α = 0.94, M = 5.02, SD = 1.31) Items for perceived ease of use include: (1) Using ILTs is easy for me; (2) When using ILTs, I find it easy to do what I want it to do; (3) I find my interaction with ILTs to be clear and understandable; (4) I find ILTs to be flexible to interact with; (5) It was easy for me to become skillful at using ILTs; (6) I find ILTs easy to use. (Cronbach's α = 0.91, M = 5.23, SD = 0.12)

Compatibility was measured with three items adopted from [49]: (1) Using online ILTs is compatible with the way I like to study; (2) Using online ILTs fits with my lifestyle; and (3) I think that using online ILTs fits well with the way I like to study. (Cronbach's α = 0.93, M= 4.76, SD= 1.53)

Attitudes toward the ILTs were measured on a 7-point scale using 12 adjectives (organized, good, unique, high quality, user-friendly, novel, cool, confusing, sophisticated, attractive, and appealing) adopted from [34]. (Cronbach's α= 0.92, M= 5.33, SD= 1.60)

To assess individuals' *behavioral intentions*, three Likert-type items from [50] were taken and modified. Items include: (1) I am willing to take other classes using ILTs in the future; (2) I think ILTs should be implemented in other classes; and (3) I will recommend classes using ILTs to other students. (Cronbach's $\alpha = 0.91$, M= 4.96, SD= 1.45)

Last, *GPA* was measured with an open-ended question. Students were asked to self-report their GPA.

6. Results

Interrelations among the eight variables of interest were examined using correlation coefficients. Table 1 displays the obtained zero-order correlations between innovativeness, power usage, ratings of the interactive learning tools (ILTs), and GPA. Due to the ordinal nature of the 7-point response scales, nonparametric Spearman correlations between innovativeness, power usage, and the ratings of interactive learning tools were also examined. The overall pattern of results was consistent for the parametric and non-parametric correlations (see the lower- and upper-half of Table 1). As such, we elected to emphasize the parametric correlations when evaluating the hypothesized relationships.

Table 1. Correlations between Innovativeness, Power Usage, and Ratings of Interactive Learning Tools (ILTs), $n = 259$

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1. Innovativeness	–	.63	.33	.47	.29	.33	.28	-.06
2. Power Usage	.65	–	.47	.63	.45	.42	.41	.00
3. Perceived Usefulness	.33	.42	–	.66	.75	.70	.72	.12
4. Perceived Ease of Use	.44	.58	.65	–	.69	.70	.69	.09
5. ILTs Compatibility	.23	.38	.73	.66	–	.73	.79	.10
6. Attitudes toward ILT s	.30	.38	.67	.71	.70	–	.78	.11
7. ILTs Behavioral Intentions	.22	.33	.69	.66	.77	.78	–	.07
8. GPA	-.04	.04	.13	.13	.11	.12	.09	–

Note. Parametric (i.e., Pearson) correlations are below the primary diagonal and non-parametric (i.e., Spearman) correlations are above the primary diagonal.

Overall, the pattern of relationships was largely consistent with the hypotheses; Table 2 summarizes the results of the hypothesized bivariate relationships. For Hypotheses 1 through 9, all of which pertained to innovativeness, power usage, and ratings of ILTs, the obtained all correlations exceed $r = .23$. The lowest correlation was observed between compatibility and innovativeness ($r = .23$) or power usage, $r = .38$. The strongest correlations ($r > .60$) were observed between the ratings of ease of use or usefulness of ILTs and attitudes toward and intentions to use ILTs in the future. Hypotheses 10 through 12, which pertained to perceptions of ease of use, usefulness, and compatibility of ILTs and students' GPAs, were partially supported. The magnitude of the correlations with GPA were noticeably weaker (see Tables 1 & 2). And, although perceptions of ease of use and usability were significantly related to GPA when examined individually ($p = .04$ for both), these hypothesized relationships would not have remained significant following adjustment for multiple comparisons (i.e., Bonferroni-corrected alpha was .004). Compatibility (Hypothesis 12) was not significantly related to GPA, $p = .07$.

Table 2. Summary of Hypothesized Relationships between Innovativeness, Power Usage, and Ratings of Interactive Learning Tools (ILTs)

Hypothesis	Zero-Order		Path Analysis	
	r	*p*	Std.Coef.	*p*
1. Innovativeness will be positively related to the perceived ease of use of ILTs.	.44	< .001	.10	.12
2. Power usage will be positively related to the perceived ease of use of ILTs.	.58	< .001	.51	< .001
3. Innovativeness will be positively related to the perceived usefulness of ILTs.	.33	< .001	.10	.18
4. Power usage will be positively related to the perceived usefulness of ILTs.	.42	< .001	.36	< .001
5. Perceived ease of use will be positively related to (1) attitudes toward ILTs, and (2) behavioral intention to use ILTs.	.71, .66	< .001, < .001	.44, .26	< .001, < .001
6. Perceived usefulness will be positively related to (1) attitudes toward ILTs, and (2) behavioral intention to use ILTs.	.67, .69	< .001, < .001	.24, .22	< .001, < .001
7. Innovativeness will be positively related to the perceived compatibility of ILTs.	.23	< .001	-.04	.65
8. Power usage will be positively related to the perceived compatibility of ILTs.	.38	< .001	.40	< .001
9. Compatibility will be positively related to (1) attitude toward ILTs, and (2) behavioral intention to use ILTs.	.70, .77	< .001, < .001	.34, .54	< .001, < .001
10. Perceived ILT ease of use will be positively related to students' performance (i.e., GPA).	.13	.04	.08	.24
11. Perceived ILT usefulness will be positively related to students' performance (i.e., GPA).	.13	.04	.07	.30
12. Compatibility will be positively related to students' performance (i.e., GPA).	.11	.07	.02	.81

Note: Std. Coeff. = Standardized Coefficient from Model 2.

A subsequent path analysis was conducted to further explore the interrelations among innovativeness and power usage, ratings of the ILTs, and attitudes and intentions to use such tools. Use of path analysis allowed for the relationships between the various independent variables (as depicted in Figure 1; innovativeness and power usage) and the outcome measures (i.e., attitudes toward- and intentions to use ILTs and GPA) to be evaluated, after accounting the correlations among the independent variables, mediators, and outcome measures. In addition, path analysis also allowed for isolation of the indirect portion of the hypothesized effects (i.e., the portion of the relationship that also correlates with the hypothesized mediators: perceived ease of use, usefulness, and compatibility of ILTs).

The path analysis was conducted using maximum likelihood estimation in AMOS (Version 24; [51]) from the variance-covariance matrix. Three models were estimated. All models included the same eight variables: two independent variables, three hypothesized mediators, and three outcome variables. In Model 1 only the direct effects between the independent variables and the outcome variables were freely estimated (i.e., direct effects only). In Model 2, the indirect effects through the three mediators were estimated, but the direct effects were constrained to zero. In Model 3, both the direct and indirect effects were estimated between the independent and outcome variables. Comparison of these models then reflected the incremental improvement in fit that was associated with the indirect effects (Model 2) over the direct effects alone (Model 1), and the potential improvement in fit associated with reintroducing the direct effects in concert with the indirect effects (Model 3) relative to the indirect effects alone (Model 2). As can be seen in the upper half of Table 3, the data provided significantly better fit to Model 2 than Model 1, $\Delta\chi^2(15) = 661.19$, $p < .001$. When the direct effects were reintroduced in Model 3, however, the fit improvement associated with these six paths was not significant, $\Delta\chi^2(6) = 10.40$, $p = .11$. As such, it was determined that Model 2, which contained only indirect effects between innovativeness and power usage and the three outcomes measures provided the most parsimonious summary of the obtained data.

Table 3. Path Analysis Model Fit Indices and Model Comparison

Model Description	*df*	χ^2	*p*	CFI	IFI	SRMR	CAIC
Hypothesized Models							
1. Direct Effects Only	21	1000.43	< .001	.176	.181	.403	1098.78
2. Indirect Effects Only	12	349.63	< .001	.716	.720	.178	506.99
3. Both Direct & Indirect Effects	6	339.23	< .001	.720	.725	.177	535.94
Additional Bidirectional Paths Correlated Errors							
A. Among Mediators	9	61.51	< .001	.956	.957	.035	238.54
B. Among Outcomes	9	297.79	< .001	.757	.761	.171	474.82
C. Among Mediators & Outcomes	6	9.67	.139	.997	.997	.023	206.37

Note. CFI = Comparative Fit Index; IFI = Incremental Fit Index; SRMR = Standardized Root Mean Residual; CAIC = Contemporary Akaike Information Criterion; Contemporary cutoff criteria for close fit suggest IFI and CFI values close to .95 or higher with an SRMR close to.08 or lower [52]. Models with lower CAIC values are considered to provide a better compromise between model fit and parsimony. $n = 259$.

Even so, it should be noted that overall fit of Model 2 (as well as the other models) was well below contemporary criteria for overall fit [52]. Modification indices suggested inclusion of bidirectional paths among the three mediators and between attitudes and intentions. As displayed in the lower half of Table 3, inclusion of bidirectional arrows among the mediators (Model A) or in combination with bidirectional arrows among the outcome variables (Model C) was associated with substantial improvements in overall fit. Most importantly, once bidirectional paths were included among the hypothesized mediators overall model fit met or exceeded contemporary criteria for close fit (see note on Table 3), yet the same pattern of significance for the paths of interest was obtained. Standardized estimates were also similar to those reported in Table 2. As such, we proceeded to interpret the indirect only model (Model 2) as originally hypothesized, with improved confidence that the lack of fit could be attributed to omission of paths that were not germane to the primary hypotheses.

As can be seen in Figure 2, power usage showed significant relationships with all three hypothesized mediators (bolded coefficients), whereas innovativeness did not. As hypothesized, all three mediators remained significantly related to attitudes toward ILTs and behavioral intentions to use ILTs after accounting for other paths and relationships in the path analysis.

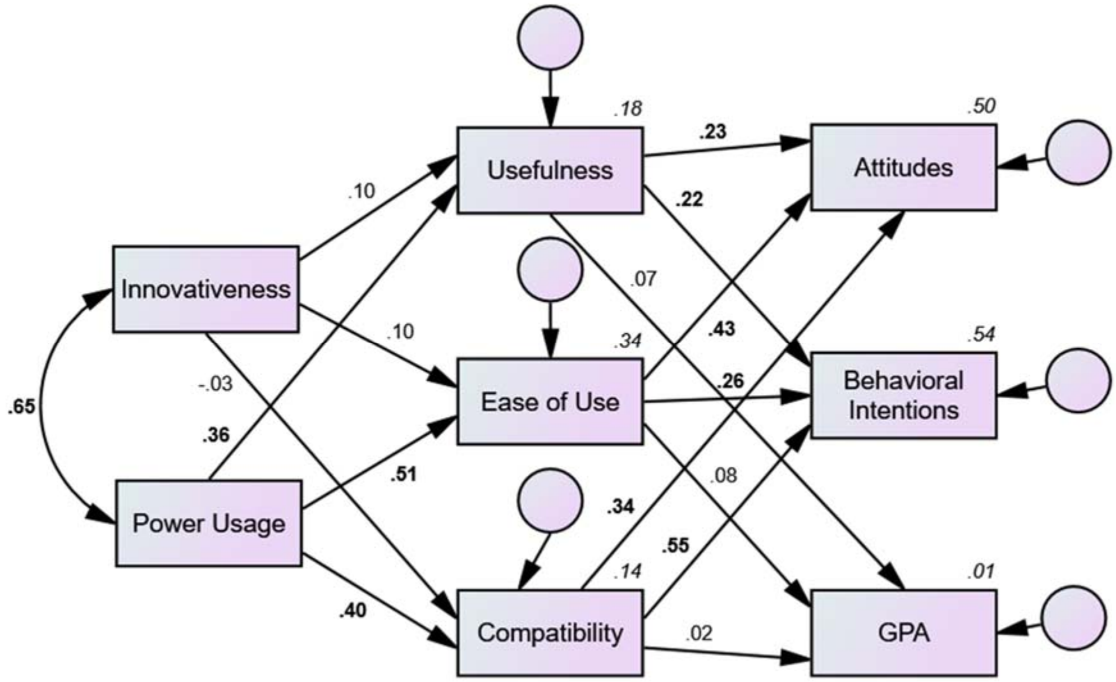

Figure 2. Standardized path analysis results for indirect effects only model (Model 2 in Table 3). **Bolded** coefficients are statistically significant ($p < .001$). *Italics* indicate the proportion of variance in the hypothesized mediators and outcome measures that was explained by the model.

This pattern of results suggests that power usage, as opposed to innovativeness, provides the primary predictive power for attitudes toward and behavioral intentions to use ILTs. Further, bootstrapped estimates of the magnitude of the indirect effects [53] from power usage through usefulness, ease of use, and compatibility did not include zero for attitudes to use ILTs (indirect effect = 0.51, 95% *CI* of 0.33 to 0.70; standardized indirect effect of .44) and behavioral intentions to use ILTs, (indirect effect = 0.67, 95% *CI* of 0.43 to 0.93; standardized indirect effect of .43). The same pattern did not hold, however, when the indirect effects of innovativeness on attitudes toward ILTs and behavioral intentions to use ILTs were considered, standardized indirect effects of .06 and .04, respectively. Overall, the pattern of results obtained via the path analysis are consistent with usefulness, ease of use, and compatibility serving as (full) mediators of the relationships between power usage and attitudes toward and intentions to use ILTs. Although innovativeness appeared to also be predictive in the early correlational analyses (see Table 1), it was no longer significant after accounting for shared variability with power usage and the other variables in the model. Overall, the three mediators, including the indirect effect of power usage, explained 50% and 54% of variance in attitudes toward ILTs and behavioral intentions to use ILTs, respectively. Only negligible variance (1%) in GPA was predicted by the other variables in the model.

7. Discussion

The present study explored the effects of individuals' technology-associated characteristics (i.e., innovativeness and power usage) on their evaluations of such tools and their academic performance using path analysis. In particular, this study examined the effects of three mediators, perceived usefulness, perceived ease of use, and perceived compatibility, postulating that technology-associated characteristics would lead to different evaluations of ILTs, which, in turn, result in different attitudes, behavioral intentions, and academic performance.

First, as postulated, the results show that power usage has significant influence on perceptions of ILTs, which is in accordance with previous findings [34]. Specifically, students with skills in using technologies are more likely to perceive ILTs as useful, easy to use, and compatible with their lifestyles. These results imply that instructors should consider students' technological skills before deciding whether to use ILTs. As such, when instructors do implement ILTs for their course, they need to establish the implementation by projecting students' individual skills associated with technology into the tools. For example, if, overall, students of the course have relatively low levels of skills in technology, a traditional teaching method might be better than the use of ILTs. If most students in a class show greater skills in technology, then the use of ILTs can be used more effectively. Therefore, the tools can give instructors the chance to enhance their courses by keeping students engaged and motivated. This finding is particularly meaningful in that it confirms the potential of ILTs for our new tech-savvy generation.

However, innovativeness did not show any significant relationships with all three hypothesized mediators, even though it was highly correlated with three mediators in correlational analyses. This implies that there is considerable overlap between innovativeness and power usage (note the correlation of .65 in Table 1 and Figure 2), and that after accounting for the shared variability with power usage in the path analysis, innovativeness no longer provided much unique explanatory power. Future research should further explore the relationship between innovativeness and power usage and how they contribute, both in combination and uniquely, to understanding student outcomes.

In addition, the present study also demonstrates that such different perceptions eventually lead to different attitudinal and behavioral outcomes, such that individuals with greater perceptions of usefulness, ease of use, and compatibility held more favorable attitudes toward the tools and willingness to use them in the future. These results imply that students' positive evaluation on the tools' usability, usefulness, and compatibility are key psychological factors of improving attitude and behavioral intention to use technological tools. Therefore, instructors need to organize online course subjects and/or activities (e.g., quizzes, assignments) with less complexity, given that increased complexity caused by poor design or organization can impact attitudinal and behavioral outcomes. Reducing complexity in online courses ensures that the course design does not hinder students' positive experience with the tools. Similarly, as our findings showed, instructors need to enhance the tools' usefulness by strategically using interactive features depending on course purpose and nature of the subject. For example, ILTs can be used to support pedagogical needs in multiple ways. The most traditional implementation was for instructors to use an interactive textbook provided by ILTs as a pre-lecture assignment to ensure students interact with the reading assignments and come to class prepared. Following lecture, ILTs have end-of-chapter problems that can be assigned such that students are graded and receive instantaneous feedback as they complete problem sets. Other instructors use a combination of an interactive textbook and fundamental end-of-chapter questions prior to class as a content delivery method. These ILTs have a rich set of reporting and analytics that can drive flipped and just-in-time teaching techniques. Students receive a great deal of data and reports, too, which can be used throughout the course for exam preparation. Since an interactive textbook, in particular, adapts to the individual students, it helps greatly to focus students on retaining information. Furthermore, instructors can enhance compatibility of the tools by utilizing features that are frequently used in students' daily lives.

One interesting result was that positive evaluations of ILTs had no effect on academic performance. The reason for this may be explained by considering how "academic performance" was measured. We used GPA as an indicator of academic performance; however, GPA may not be an accurate representation of academic performance, especially performance achieved through the use of ILTs. Students' GPAs reflect their overall academic performance over all courses that they have taken, some of which may not have employed ILTs. Therefore, GPA might not directly correspond to their academic performance using ILTs. Some might suggest measuring students' grades in a particular course. However, this data was gathered in the middle of a semester, and as such, we were unable to gather enough grade data for the students. Furthermore, given that we did not recruit participants from the same course or from the same university, it is hard to treat every participant's grade equally. Thus, to see how the use of ILTs actually improves students' academic performance, we should conduct an experiment by comparing a group of students who use ILTs with a group of students who do not use such tools for learning the same subject. This method can more clearly show how the use of ILTs transfers to improved academic performance.

This study has several limitations. First, the results are based on the analysis of 259 responses from undergraduate and graduate students. Thus, more responses are currently being gathered to further validate the results. Second, this study used participants who have used two specific ILTs (i.e., SmartBook and Connect), which might limit the generalizability of the results. Although two examples of ILTs have representative characteristics of general ILTs, it would be worth examining the effects of other examples of ILTs for a future study. This study did not ask whether they are traditional or non-traditional students but they left comments to identify themselves. The major factor that differentiates non-traditional students from traditional ones might be their age in the context of the study. However, because this study did control age in analyzing the effect of IVs on DVs, we believe that such effect might not be that significant. If this study did consider those, it could have provided us even more implications. In addition, this study did not collect data that show participants' amount of ILT usage (e.g., times/durations), given that the point of this paper is to investigate perceptions, not quantifiable data. However, it would also be a factor that can be considered.

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