

An Investigation into the Susceptibility of Engineering Students to Educational Persuasive Technology

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Summary

Research has shown that persuasive technology can successfully change people's behaviors and attitudes. Research has also shown that personalized persuasive technology is more effective at achieving desired goals than a one-size-fits-all approach. However, few studies have focused on the impact that personalized persuasive strategies have had on engineering education when these strategies account for different student attributes. This paper addresses this topic by investigating engineering students' susceptibility ($n = 260$ students) to five commonly used persuasive strategies in persuasive technology design, specifically Reward, Competition, Social Comparison, Trustworthiness and Social Learning. The results indicate that students are more likely to be susceptible to Trustworthiness and Reward strategies, followed by Competition, Social Learning and then Social Comparison. This study also highlights differences in susceptibility to certain persuasive strategies between different gender types, age groups and student education levels.

Key words:

Persuasive Technology; Persuasive Strategies; Personalization; Persuasion in Education; Educational Technology.

1. Introduction

Many researchers across multiple disciplines, including Human-Computer Interaction (HCI), cognitive science and psychology, focus on the theoretical foundations of positive change in the human mind, human behavior and human attitudes, and how to design technology to support these processes [1]. Persuasion is a process that successfully supports or modifies a person's behavior, opinions or affection about an issue or action [2, 3]. Persuasion involves designing human communication to change the independent judgments and actions of others [4, 5]. Persuasive Technology (PT) has emerged as a sub-discipline of HCI within the last two decades; in that time, interest has grown in how PT can be applied to systems design [6]. PT involves using computers and software to alter or enhance the attitudes and behavior of users [2, 7]. Changing a person's behavior or attitude using PT should be accomplished

without user persecution, coercion, or deception, and only through persuasion and social influence [2, 4]. PT can be designed and mediated, for example, via the Internet and via web and mobile applications that serve as environments designed to increase the effectiveness the persuasive interaction [4, 8]. PT can be applied in fields like business, health and education to motivate people to achieve their goals [9].

Regarding PT in business, a study conducted by [10] examined online persuasive features used in popular e-commerce websites to influence people's purchasing behavior. For example, websites like eBay rely on a rating system to indicate buyer and seller feedback using a colored star next to the users' names to indicate the user's reputation. That reputation rating then motivates or persuades others to either sell to or buy from that particular user. Regarding PT in healthcare, providers send emails to motivate and follow up with patients who are interested in quitting smoking [11]. In education, students currently use mobile phones, tablets and laptops in their classes and lectures, or off-campus, to read, record or search for relevant information. The studies conducted by [12, 13] showed that PT could be applied in this realm to address students' poor study behaviors, which could lead to improved academic performance and more motivation.

Educational PT aims to use different, personalized persuasive strategies to motivate, engage and support students in a way that leads them to better academic performance. For example, [14] applied PT to develop supportive tools for the student. They found that those tools increased students' positive attitudes toward the education process. Likewise, [15] also used PT in the classroom by sending motivational students text messages. The results showed that students who received a persuasive message performed better in the classroom than those that did not. [16] also investigated students' academic performance, suggesting that PT could be applied to create a learning environment based on each student's study habits that could increase the student's motivation to learn. In the study they tested persuasive tools to facilitate and enhance mathematics instruction, which yielded promising results [17]. [18] integrated persuasive strategies and Web 2.0 into online learning. The results showed that online learning

could improve student achievement when it relied on a persuasive concept.

However, the main issue is that the personalization of PT is rarely applied in education [18-21]. Additionally, studying how different students are susceptible to different persuasive strategies is a prerequisite to designing effecting and adaptive educational PT in engineering education specifically; adapting persuasive strategies to the different characteristics of students is challenging [21, 22]. This paper aims to bridge that gap by exploring students' susceptibilities to common persuasive strategies to support the design of effective and personalized educational persuasive systems. Specifically, this study focuses on five critical persuasive strategies: Reward, Competition, Social Comparison, Trustworthiness, and Social Learning.

Reward involves offering incentives as the individual progresses toward a desired outcome [20, 23]. The Reward strategy is mostly implemented in PTs through badges, points and increases in rank as individuals make progress in the desired behavior [24]. Competition leverages human beings' innate drive to compete against others to motivate users to adopt a target attitude or behavior [25]. Social Comparison focuses on comparing people against one another [23, 25], which might motivate them not only by monitoring and reporting or ranking their performance but also by comparing their progress against others that are aiming to achieve the same goals. Trustworthiness is chiefly related to system-oriented aspects; it involves providing information that is truthful, fair, and unbiased which, in turn, increases its persuasive power. Social Learning motivates behavior by allowing people to observe, imitate and model their behavior against others. In persuasive systems, the Social Learning strategy can be implemented in multiple ways such as sharing the test scores, decisions or methods of successful students with other students so that they might want to take action to imitate their success.

We used these five strategies because they are the most common in the educational use of PT and because of their relevance to this study [26, 27].

The main research questions that are investigated in this paper are:

1. To what extent are engineering students susceptible to the overall persuasive strategies?
2. How do students differ in terms of their susceptibility to each persuasive strategy?
3. Does gender type affect the perceived persuasiveness of each strategy?
4. Does educational level affect the perceived persuasiveness of each strategy?
5. Does age affect the perceived persuasiveness of each strategy?
6. Is there any significant difference when comparing persuasive strategies pairwise?

To answer the research questions, we conducted a study with 260 higher education students in Saudi Arabia. The results generally indicated that students are more likely to be persuaded by Trustworthiness and Reward, followed by Competition, Social Learning and then Social Comparison, in that order, regardless of the influence of other attributes such as gender, age, education and specialization. Regarding the perceived persuasiveness of Trustworthiness and Reward, there was no significant difference when compared pairwise. Since students are generally more easily persuaded by these two strategies, Trustworthiness and Reward should be given a higher priority in the design of persuasive educational systems.

2. Method

This study examined students' susceptibility to certain persuasive strategies in PT design to answer pre-defined research questions. We used the Persuadability Inventory (PI) tool developed by [28] for use in education and used by other relevant work [7, 18, 29]. We used the PI to measure the students' susceptibility to the five persuasive strategies. The tool consists of 25 items, where each item can be ranked using a 7-point Likert scale ranging from (1) Strongly Disagree to (7) Strongly Agree. The Reward strategy contains six items; Competition has five items; Social Comparison involves six; Trustworthiness consists of three; and Social Learning includes five.

Regarding the reliability of the PI tool, we ran Cronbach's coefficient alpha (α) overall and for each component according to the data obtained from this study. The overall reliability was 0.88, indicating excellent reliability. The reliability results for the components of Reward, Competition, Social Comparison, Trustworthiness, and Social Learning were 0.79, 0.74, 0.80, 0.70 and 0.80, respectively. These values confirm the good reliability of each component. Therefore, reasonable comparisons and data analyses can be made using the data.

Additionally, we performed a Shapiro-Wilk normality test on the data to determine which type of analysis to conduct. This test showed that our data is not normally distributed; none of the components met the significance level (Sig. < 0.05). As a result, we conducted a non-parametric analysis (a Repeated Measures Analysis of Variance, or RM-ANOVA) in this study.

We distributed the PI survey to participants via email and social media platforms. There were 260 valid respondents to the survey: 162 males (62.3%) and 98 females (37.7%). The participants were higher education students from Saudi Arabia majoring in computer science and engineering with different educational levels. Their ages ranged from 20 to 50 years old.

3. Results

3.1 Persuasive strategies (overall)

Regardless of any variables, all five persuasive strategies except Social Comparison had an average rating greater than or equal to the neutral score of 4, as shown in Fig. 1. According to the findings, students were most likely to be persuaded by Trustworthiness and Reward, followed by Competition, Social Learning, and then Social Comparison.

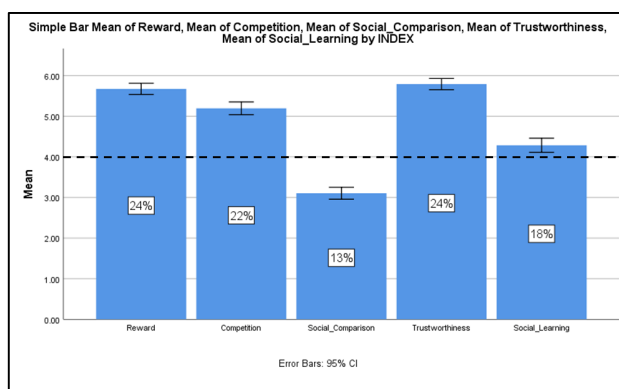


Fig. 1 Overall mean ratings of the persuasive strategies

3.2 Persuasive strategies and gender

Fig. 2 shows that male students found Trustworthiness to be the most persuasive strategy, followed by Reward, Competition, Social Learning, and then Social Comparison. Female students found Reward to be the most persuasive strategy, followed by Trustworthiness, Competition, Social Learning, and then Social Comparison. In general, Trustworthiness and Reward together are considered the most effective persuasive strategies regardless of gender.

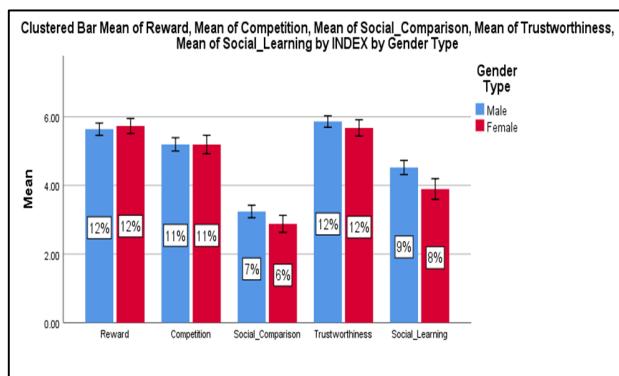


Fig. 2 Overall mean ratings of the persuasive strategies based on the gender type

We also used an RM-ANOVA for each persuasive strategy to find out if there were statistically significant differences when accounting for gender. Table 1 and Fig. 3 show the influence of gender on the perceived persuasiveness of each strategy. There were no statistically significant differences between gender and the Reward, Competition and Trustworthiness strategies, meaning gender had no main effect on these persuasive strategies (Sig. > 0.05). However, there were statistically significant differences along gender lines for the Social Comparison and Social Learning strategies (Sig. < 0.05).

Table 1: The influence of gender type on the perceived persuasiveness of each persuasive strategy

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Reward	Between Groups	.541	1	.541	.425	.515
	Within Groups	327.888	258	1.271		
	Total	328.429	259			
Competition	Between Groups	.001	1	.001	.001	.978
	Within Groups	426.591	258	1.653		
	Total	426.592	259			
Social Comparison	Between Groups	7.934	1	7.934	5.535	.019
	Within Groups	369.818	258	1.433		
	Total	377.752	259			
Trustworthiness	Between Groups	2.096	1	2.096	1.661	.199
	Within Groups	325.578	258	1.262		
	Total	327.674	259			
Social Learning	Between Groups	24.108	1	24.108	12.441	.000
	Within Groups	499.956	258	1.938		
	Total	524.064	259			

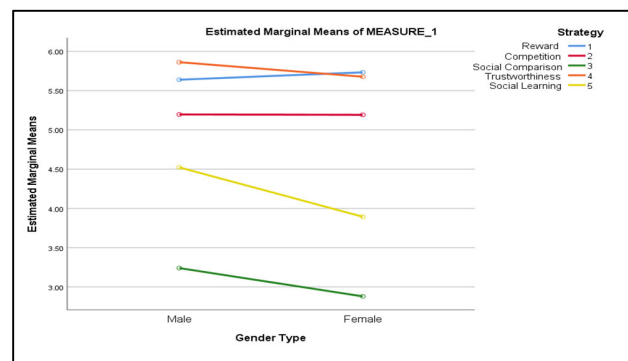


Fig. 3 The influence of gender type on the perceived persuasiveness of each persuasive strategy

3.3 Persuasive strategies and age

The persuasiveness of each strategy was similar for each age group, as shown in Fig. 4. All students answered that Trustworthiness and Reward were the most effective strategies to use to change their behavior and attitudes, followed by Competition. Social Learning, and Social Comparison were the least preferred persuasive strategies for all age groups.

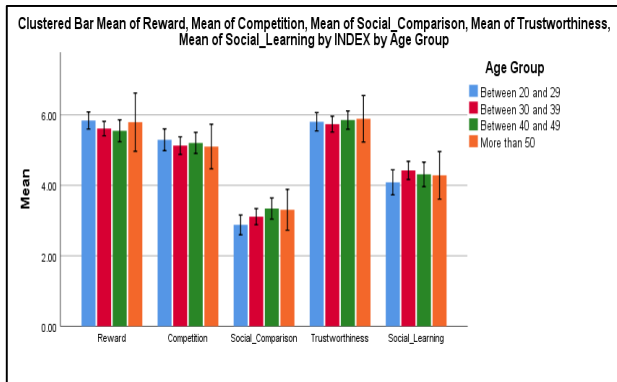


Fig. 4 Overall mean ratings of the persuasive strategies according to age group

Again, we used an RM-ANOVA for each persuasive strategy to determine if there were any statistically significant differences between perceived persuasiveness and age. Table 2 and Fig. 5 show the influence of age on the perceived persuasiveness for each strategy. Generally, the results indicated that there were no statistically significant differences between the age groups and their belief in which strategies were more or less persuasive. Therefore, age had no main effect on these persuasive strategies ($\text{Sig.} > 0.05$).

Table 2: The influence of the age group on the perceived persuasiveness of each persuasive strategy

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Reward	Between Groups	3.781	3	1.260	.994	.396
	Within Groups	324.648	256	1.268		
	Total	328.429	259			
Competition	Between Groups	1.377	3	.459	.276	.842
	Within Groups	425.215	256	1.661		
	Total	426.592	259			
Social Comparison	Between Groups	8.159	3	2.720	1.884	.133
	Within Groups	369.593	256	1.444		
	Total	377.752	259			
Trustworthiness	Between Groups	.673	3	.224	.176	.913
	Within Groups	327.000	256	1.277		
	Total	327.674	259			
Social Learning	Between Groups	5.238	3	1.746	.862	.462
	Within Groups	518.826	256	2.027		
	Total	524.064	259			

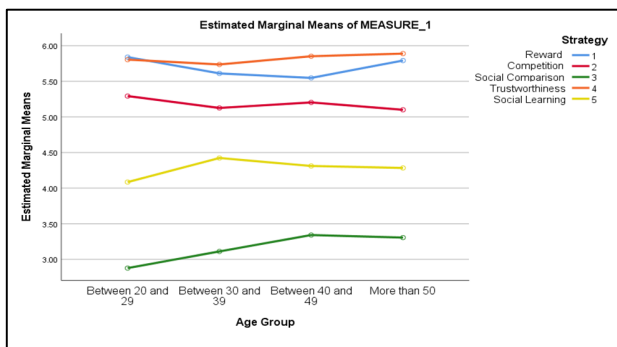


Fig. 5 The influence of the age group on the perceived persuasiveness of each persuasive strategy

3.4 Persuasive strategies and education level

Fig. 6 shows that the results indicated that students who have Bachelor's and Master's degrees believed that Trustworthiness was the most effective persuasive strategy, followed by Reward, Competition, Social Learning and Social Comparison. Students with PhDs, however, felt that Reward was the most effective persuasive strategy. Generally, as it was when analyzed along the lines of gender or age, Trustworthiness and Reward were considered the most persuasive strategies regardless of each student's educational level.

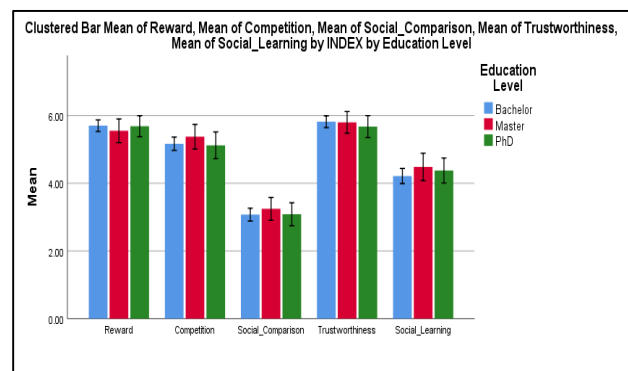


Fig. 6 Overall mean ratings of the persuasive strategies based on the education level

The results of the RM-ANOVA for each persuasive strategy when taking educational level into account are shown in Table 3 and Fig. 7. The results indicate that there were no statistically significant differences between education level and all five persuasive strategies. Therefore, education level had no main effect on these persuasive strategies ($\text{Sig.} > 0.05$).

Table 3: The influence of education level on the perceived persuasiveness of each persuasive strategy

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Reward	Between Groups	.801	2	.400	.314	.731
	Within Groups	327.628	257	1.275		
	Total	328.429	259			
Competition	Between Groups	1.785	2	.892	.540	.583
	Within Groups	424.808	257	1.653		
	Total	426.592	259			
Social Comparison	Between Groups	1.019	2	.510	.348	.707
	Within Groups	376.732	257	1.466		
	Total	377.752	259			
Trustworthiness	Between Groups	.732	2	.366	.288	.750
	Within Groups	326.942	257	1.272		
	Total	327.674	259			
Social Learning	Between Groups	2.942	2	1.471	.726	.485
	Within Groups	521.122	257	2.028		
	Total	524.064	259			

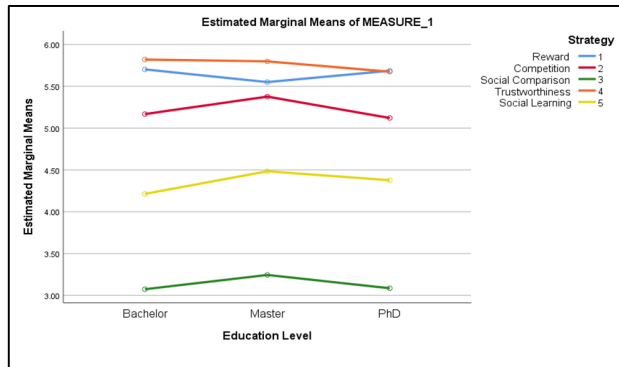


Fig. 7 The influence of education level on the perceived persuasiveness of each persuasive strategy

3.5 Pairwise comparisons of the persuasive strategies

We conducted a post hoc within-group analysis (i.e., pairwise comparisons) between the persuasive strategies as shown in Table 5. The results indicated that each pair of persuasive strategies differed significantly ($\text{Sig.} < 0.05$) except for the pair of Reward and Trustworthiness, where there were no statistically significant differences between their mean values ($\text{Sig.} > 0.05$). This suggests that Reward and Trustworthiness should be prioritized in persuasive educational systems since they have the highest mean ratings and therefore the greatest likelihood of success in changing student behavior and attitude.

Table 4: Overall pairwise comparisons between the persuasive strategies

Paired Samples Test		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Reward-Competition	.47974	1.45140	.09001	.30249	.65699	5.330	259	.000
Pair 2	Reward- Social Comparison	2.57051	1.36582	.08470	2.40372	2.73731	30.347	259	.000
Pair 3	Reward-Trustworthiness	-.11795	1.29704	.08044	-.27635	.04045	-1.466	259	.144
Pair 4	Reward- Social Learning	1.38897	1.43800	.08918	1.21336	1.56459	15.575	259	.000
Pair 5	Competition – Social Comparison	2.09077	1.37488	.08527	1.92287	2.25867	24.520	259	.000
Pair 6	Competition - Trustworthiness	-.59769	1.33931	.08306	-.76125	-.43413	-7.196	259	.000
Pair 7	Competition – Social Learning	.90923	1.54532	.09584	.72051	1.09795	9.487	259	.000
Pair 8	Trustworthiness – Social Learning	1.50692	1.37955	.08556	1.33845	1.67540	17.613	259	.000

4. Discussions

This study investigated the susceptibility of engineering students from Sadia Arabia to the five main persuasive strategies (Reward, Competition, Social Comparison, Trustworthiness and Social Learning) used in PT design. The study collected data from 260 university engineering

students and graduates: 162 males and 98 females of different age groups, education levels and specializations. The findings show that students can generally be persuaded to achieve their learning goals when exposed to different persuasive strategies. These findings answer the first research question about the extent to which students are susceptible to the overall persuasive strategies. The students believed that they needed some motivational mechanisms to support their learning; this motivation can successfully be provided using different persuasive strategies in PT, as indicated by the fact that students' responses for each strategy were more than average.

Regarding the difference in the susceptibility of students to each persuasive strategy, we found that the students did differ in their susceptibilities. Irrespective of gender, age, education level or specialization, students believed that two main persuasive strategies could be used to help them achieve their learning goals. These two strategies were Trustworthiness and Reward. This implies that students may be more motivated to accomplish their learning goals by an educational system that is trustworthy, reliable, secure and transparent. Students may initially need to build this trust relationship with the educational system in which they find themselves to learn effectively. For example, an educational system that offers each student an online profile page that keeps track of their achievements and the tasks they still must complete might show the student that the system is trustworthy and that it is aware of and values their achievements. In the field of education, students may be more likely to change their behaviors and attitudes when they can trust their educational institution and know precisely what is expected of them. Additionally, adding Reward features into educational systems can give these systems an advantage since students require motivation continually to stay focused on accomplishing their learning tasks. The Reward features involve, for example, points, badges, ranks, and levels that can be incorporated into gamified educational systems as an application PT that increases enhance their motivation [24].

Supporting healthy Competition among students that are more susceptible to the Reward strategy can also enhance motivation. Research [30] indicates that people's tendency to be competitive is likely to be influenced by their natural drive for rewards; t irrespective of gender and culture [31], the more individuals are susceptible to rewards, the more susceptible they will be to Competition. In PT for education, when designers need to implement a persuasive system for a non-social context, the Trustworthiness (reliability) of the system and the Reward features should be prioritized. When designers need to deploy a persuasive system supporting social and collaborative interaction between students, however, Competition should also be considered.

The persuasive strategies of Social Learning and Social Comparison were found to be the least effective. The

Social Learning strategy may not be preferred because students may value their privacy and might not want to share their specific achievements or approaches with others. The Social Comparison strategy, which was the worst performing strategy of all, might be so ineffective because students feel cautious when comparing themselves to others, or they might be afraid of being classified or characterized as weak or lazy students. The results of this research suggest that neither of these strategies would be particularly effective in getting students to alter their behavior and attitudes to achieve their goals.

When considering gender, the results indicated that there was no significant difference on the perceived persuasiveness of the top three persuasive strategies including Reward, Competition, and Trustworthiness. Both males and females agreed that these three strategies were the ones most likely to motivate them to change their behavior and attitudes toward studying. PT designers in education should focus on using these three strategies in persuasive educational systems regardless of student gender. However, there was one slight difference between genders that appeared in testing the persuasiveness of Social Comparison and Social Learning strategies. Female students seemed to be more suspicious of Social Learning and Social Comparison strategies than male students. The reasons for why this might be the case cannot be generalized to other cultures since this particular finding is linked to the specific sample of this study, but this case should be more carefully explored in future studies.

Considering different age groups, our research found that age had no significant influence on the persuasiveness of the five persuasive strategies. Thus, when designing persuasive educational systems, age should not be considered a factor. The same findings were found when comparing students along the lines of their educational background. This study obtained data from students and graduates of varying educational levels (Bachelors, Masters and PhDs) and found no significant difference between the students with different educational histories. Thus, personalizing persuasive educational systems according to both age and educational level may not be as important as it might have seemed in the past.

By comparing persuasive strategies pairwise, the post hoc within-group analysis (i.e., pairwise comparisons) indicated that each pair of persuasive strategies differed significantly except for the pair of Reward and Trustworthiness. According to the findings, among the five commonly employed persuasive strategies investigated, Trustworthiness and Reward were the most effective persuasive strategies, followed by Competition, Social Learning, and then Social Comparison. The two strategies of Social Learning and Social Comparison were the least favored. When designers of persuasive educational systems want to incorporate the lower-performing strategies, they should carefully consider the limited, specific cases where

Social Learning and Social Comparison can play an effective role in enhancing the students' behavior and academic performance.

Since these claims are based solely on the data obtained from this study, more empirical studies are needed at higher education in other countries to confirm them. Nonetheless, this study's findings provide an initial insight into how to design effective, personalized persuasive systems for use in an educational context.

5. Conclusion and Future work

Regardless of gender, age and education level, students are more likely to be persuaded by Trustworthiness and Reward strategies, followed by Competition, Social Learning, and then Social Comparison strategies. The results of our study also indicated that each pair of persuasive strategies significantly differed except for the Reward and Trustworthiness pair. Thus, among the five investigated persuasive strategies, Trustworthiness and Reward should be given the highest priority in PT design for engineering education.

Future research directions will involve larger samples from different cultures and contexts to repeat the findings and make them more generalizable. Moreover, implementing and comparing different instances of persuasive educational systems adapted to students' different characteristics and testing their effectiveness would also be of great research value.

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