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Proactivity Affects Triggered and Maintained Situational Interest and Relates to Perceived Learning Values of Attending a Hands-on Making Contest

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Abstract

This study explored how proactivity triggers and maintains the interest and perceived learning values of students. It surveyed students who participated in a science and technology hands-on making contest. This contest required students to make three miniatures and use them to compete in relay races and tug-of-war competitions. Data from 197 participants were collected analyzed using confirmatory factor analysis with structural equation modeling. Participants consisted of 135 (68.5%) male students and 62 (31.5%) female students. 91 participants were in the fifth grade (46.2%) and 106 were in the sixth grade (53.8%). Results identified positive correlations between proactivity, triggered interest, maintained interest, and perceived learning value. The coefficients were .64, .28, .59, .36, and .47, respectively, and the effect sizes were strong. These results indicated that although failure in miniature design is unavoidable, promoting students' proactivity can reduce failure, facilitate situational interest, and ultimately enhance perceived learning values.

Keywords: hands-on making, maintained interest, perceived learning values, proactivity, triggered interest

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Introduction

Individuals who are proactive have been shown to be creative (Kim, Hon, & Crant, 2009). Creativity involves a future-oriented vision to generate new and better ways of doing things (George & Zhou, 2001) by challenging the status quo. This is also a common element in most forms of proactive behavior. Moreover, individuals who are proactive are believed to be motivated to learn new things because they tend to feel responsible for improving the situation (Kim et al., 2009). PowerTech is a hands-on making contests that students must identify the cause of a particular problem before they can solve the problem during the contest. To work efficiently and effectively, it is necessary to proactively identify the problem and find the solution to prevent errors from occurring. Consequently, students could perceive learning values of attending a hands-on making contest (hereafter "perceived learning values").

STEAM education is an integrated concept of learning. How to cultivate students' integrated ability in learning is the key of STEM education (Fan & Yu, 2016). Project-based Learning (PBL) encourages students to learn and apply knowledge and skill through an engaging experience, and developed a product at the end for measuring (Vogler et al., 2018). Combining the concept of both STEAM education and PBL, PowerTech contest is a way that could measure students' STEAM integrated ability, engagement and also their learning outcomes. Previous research (e.g., Avsec, Rihtarsic, & Kocijancic, 2014; Boyce, Mishra, Halverson, & Thomas, 2014) has found that students tend to lose interest in science as they grow older. Researchers have suggested that students' Situational Interest (SI) has a phase in which interest is triggered and a subsequent phase in which it is maintained (Dewey, 1913; Hidi & Renninger, 2006). Special activities may enable students to generate domain-specific learning interests (Durik, Shechter, Noh, Rozek, & Harackiewicz, 2015; Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Concerning domain-specific learning, science and technology contests can revitalize students' interest in science and technology learning. PowerTech is a STEAM hands-on PBL contest that students' minds to overcome issues might arise during the making process. As emotional factors can predict problem solving strategies used in problem solving (Muis, Psaradellis, Lajoie, Di Leo, & Chevrier, 2015), PowerTech may evoke students' minds to overcome issues that arise in the miniature making process, and motivational factors such as students' SI, may be triggered and maintained to positively affect their performance. Law, Lee, and Yu (2010) found that high-pressure or competitive contests are generally successful in stimulating participants' interest in scientific problem solving. Thus, this study investigates the students who participated in the science and technology hands-on making contest, PowerTech, and collected their feelings of interest and experiences through questionnaire for statistical analysis. Therefore, the purpose of this study was to explore the correlation between proactivity, triggered and maintained interest and perceived learning values in the context of the PowerTech contest.

The Essence of PowerTech

In the process of hands-on learning approaches, knowledge can be transferred and competence can be developed (Cachay & Abele, 2012). Participants are required to make miniatures with team members in the morning of the contest by using a fixed set of parts that include a motor, battery pack and wires, driving gears, wooden ice pop sticks and nuts and bolts. During the construction process, participants need to apply techniques and materials to build miniatures, delegate and coordinate tasks, test and modify their designs. After the construction phase is complete, the participants use the miniatures they produced to compete against other teams' miniatures in relay races and tug-of-war.

The students are required to make three miniatures in PowerTech contest. Take "The King of Animals" for example (Figure 1), miniature is a four-legged animal driven by a motor. With a well-designed connecting rod, "The King of Animals" can walk precisely. To win the relay race, the miniatures need to obtain and maintain the greatest acceleration and fastest pace; whereas the key to winning the tug-of-war resides in whether the miniatures can walk steadily with the required amount of friction. Ultimately, making the miniatures requires problem solving skills to optimize the power transformations that enhance the quality of the miniatures. Engineering design thinking is a complex learning process, and PBL can evaluate students' learning outcome (Dym, Agogino, Eris, Frey, & Leifer, 2005). PBL enhances students' acquisition of competencies specific to each subject and the development of general competencies such as communication and team work that are increasingly valued (Hong, Chen, & Hwang, 2013). However, PowerTech is a kind of PBL hands-on contest that those three miniatures can be evaluated the performance of the team.

Literature Review

Proactivity

Proactive behavior refers to the anticipatory action that individuals use to impact themselves and/or their environments. For example, in hands-on jobs, proactive behavior can help to implement ideas and solve problems in advance to prevent mechanical errors (Parker, Williams, & Turner,

Figure 1. Example of "The King of Animals"

2006). Most research on proactive behavior has been phenomenon-driven whereby researchers have noticed a particular behavior and then developed a theory and collected data to describe, predict and explain it as a distinct phenomenon (Grant & Ashford, 2008). Existing research provides extensive evidence supporting the different ways in which students can express proactive behavior. Examples of this can be seen with hands-on jobs (Wrzesniewski & Dutton, 2001), breaking rules (Morrison, 2006), implementing ideas and solving problems (Parker et al., 2006). Proactive behaviors are self-initiated, future-focused and involve taking initiative to cause change (Parker & Collins, 2010).

In the process of making the miniatures, students may encounter failures, such as the miniature is unable to walk or unable to walk in a straight line. If students with a sense of proactivity will be able to observe basic dimensions, antecedents, processes and consequences to avoid the same failure when the miniature is rebuilt. Thus, the role that proactivity plays as an antecedent of SI in the designing of miniatures is explored in this study.

Triggered and Maintained Interest

SI has been defined as an immediate affective response to certain conditions and/or stimuli in the learning environment (Hidi, 1990). SI focuses one's attention on the task but it may or may not endure over time (Hidi & Renninger, 2006). Although SI has been extensively studied in the context of text comprehension, it has rarely been examined in the context of hands-on making (Jetton & Alexander, 2001). SI may be increased when learners perceive knowledge gaps (Rotgans & Schmidt, 2014). While triggered interest depends solely on environmental factors, maintained interest depends on the learning environment to help support students' interest (Lo, 2015). SI may be increased from the involvement of hands-on activities (Schwartz & Martin, 2004). Therefore, PowerTech may be an appropriate agent for investigating SI (Rotgans & Schmidt, 2011) in relation to science (Hulleman & Harackiewicz, 2009) and mathematics (Høgheim & Reber, 2015).

Previous studies have outlined the benefits of PBL with collaboration and competition (e.g., Regueras, Verdú, Verdú, & de Castro, 2011) especially increasing motivation and interest of students (Frank, Lavy, & Elata, 2003) and developing skills increasingly in demand in the real world that classical methods are unable to develop (Regueras et al., 2011). Moreover, PBL is fundamental to the PowerTech contest as it requires continuous problem-based learning to promote participants' interests during miniature making (Rotgans & Schmidt, 2012). Thus, this study focused on how participants' SI is triggered and maintained during the course of preparing for and participating in PowerTech.

Interactionist theory has garnered attention on activation theory, which suggests that the behavioral manifestation of underlying traits would be modified by situational determinants (Geukes, Mesagno, Hanrahan, & Kellmann, 2012). By contrasting performance contextualized within repetitions of the same challenge, it could be possible to gauge the extent to which triggered interest is the leading element of maintained interest. In the context of PowerTech, this would involve the students repetitively finding failures in their miniatures' design and modifying them. This would motivate students with learning value when the students' goal is to win PowerTech.

Perceived Learning Values

Perceived learning is considered as an indicator of learning (Alqurashi, 2019), and can be seen as the self-report of learners' reflection and introspection (Bacon, 2016). Elbeck and Bacon (2015) identified that direct measures, such as scoring the performance of task and indirect measures, such as self-reports of learning can avoid the confusion between measuring recognizing and understanding. Furthermore, the PowerTech contest is a kind of indirect measurement because finished the miniatures could be seen as the learning outcome of students' perceived learning values.

Research Hypotheses and Model

While working on a hands-on making project, participants use their knowledge from past projects to proactively provide ideas for improving the current project. This positive attitude reduces participants' resistance to change and enhances interest and learning when working on projects. Accordingly, the interrelatedness between proactivity, triggered and maintained-SI as well as the perceived learning value of hands-on making are proposed as the research hypotheses guiding this study.

Proactivity Relevant to Triggered and Maintained Interest

In hands-on making projects, if participants found the design task excessively difficult they could become frustrated rather than motivated and have less interest to resolve problems (Glogger-Frey, Fleischer, Grüny, Kappich, & Renkl, 2015). Students with a high level of proactivity could avoid potential design failures that could lead to extra time spent and incurred opportunity costs (Rochlin, Sarne, & Mash, 2014). This would potentially involve several activities, for example, checking the assembling procedures prior to commencing assembly to prevent errors that would result in spending more time on re-assembling. In line with interactionist theory, this behavior would reflect on one's triggered and maintained interest in completing a task (Hidi, Renninger, & Krapp, 2004). Thus, the following hypotheses were proposed:

H1: Proactivity is positively related to triggered interest.
H2: Proactivity is positively related to maintained interest.

Triggered Interest Relevant to Maintained Interest

Hidi and Renninger (2006) proposed a model in which they described two phases of SI sequentially: (1) an initial phase in which SI is triggered; and (2) a second phase in which SI is maintained. Triggered interest can initiate this process by attracting students' attention to the material; however, this experience would not necessarily translate into maintained interest (Hidi & Renninger, 2006). This argument raised the question of whether these two types of SIs would be correlated when participants worked on hands-on making. Thus, the following hypothesis was proposed:

H3: Triggered interest is positively correlated to maintained interest.

Triggered and Maintained SI Relevant to Perceived Learning Values

Previous research has identified an incipient sense of value as indicative of SI (Knogler, Harackiewicz, Gegenfurtner, & Lewalter, 2015). As interest develops, the perception of value and knowledge develops simultaneously (Renninger & Hidi, 2011). Flowerday and Shell (2015) observed that SI had strong direct and indirect effects on learning and engagement if the specific content is meaningful or important to the individual, which relates back to the value-related component (Schiefele, 2009). Moreover, triggering and maintaining SI can be responsible for cognitive activation and, ultimately, successful learning (Ainley, 2007). Thus, whether participants' SI was related to perceived learning values was hypothesized as follows:

H4: Triggered interest is positively related to perceived learning values.

H5: Maintained interest is positively related to perceived learning values.

Research Model

Based on the above hypotheses, the research model in Figure 2 is presented for confirmatory study.

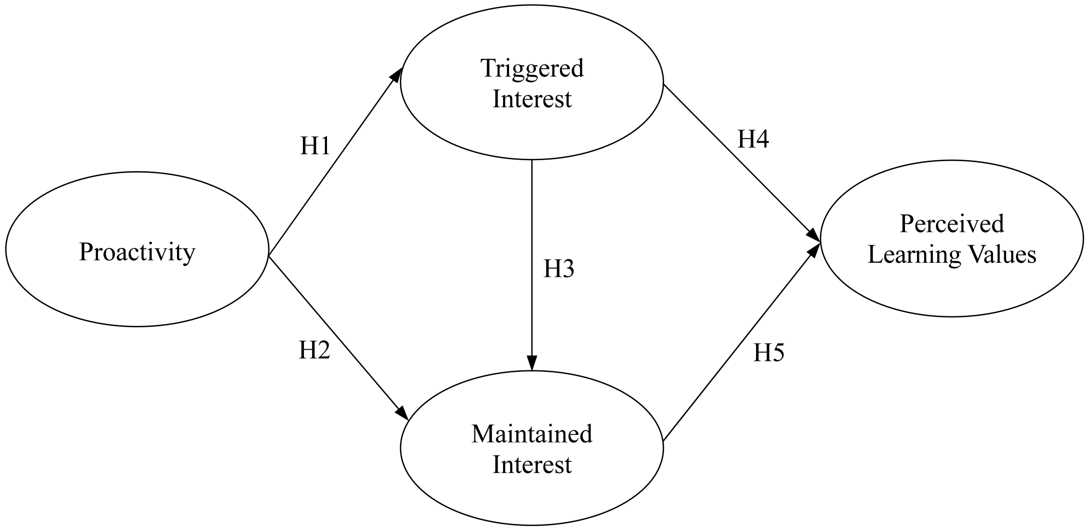

Figure 2. Research Model

Research Design

Research Procedure and Participants

Purposive sampling was used in this study. The target samples were students from junior high schools in Taiwan that participated in the PowerTech contest. The first questionnaire contains constructs of proactivity and triggered interest, were delivered to 412 students who indicated to participate in the national contest 6 months later, and 304 questionnaires were returned. When conducting research with students, this study recognized that there is a risk that students may feel obliged to participate in research projects. This risk was managed by clearly specifying on consent forms that participation in the study was voluntary. The importance of maintaining confidentiality of personal information was stressed to students. Students were aware that they were taking part in an evaluation study and that the data they provided might be published.

After the PowerTech national contest was held in December, this study administered the maintained interest and perceived learning values measures in a separate questionnaire. Questionnaires were distributed to the 236 students who participated in the national contest, and 197 questionnaires were returned, for a response rate of 83%. Only counted participants who returned the triggered SI questionnaire were counted as well as the maintained interest and perceived learning values questionnaire as effective questionnaires.

The sample was composed of 135 (68.5%) male students and 62 (31.5%) female students. There were 91 fifth grade participants (46.2%) and 106 sixth grade participants (53.8%). With respect to hours spent on designing and redesigning miniatures as an out-of-school activity (i.e., students gathered together on their own time) before the nation-wide contest, 52 (26.4%) participants worked less than 2 hours/week, 70 (35.6%) participants worked between 2.1-4 hours/week, 56 (28.4%) participants worked between 4.1-6 hours/week, and 19 (9.6%) participants worked more than 6.1 hours/week.

Measuring Questionnaire

The questionnaire items were adapted from previous theories or researchers and were obtained by professionally translating the original items to Chinese using the forward-backward method, which allows one to verify the accuracy and clarity of the translation. After the translation, the description of questionnaire items also be modified for fitting this study. Finally, the items were assessed on a five-point Likert scale ranging from 1 (“disagree strongly”) to 5 (“agree strongly”).

Proactivity: Kanse (2004) proposed a categorization of proactive actions: (1) to prevent items from becoming out of control; (2) to find the quantity, the scope and the impact of error consequences; (3) to find a temporal solution and maintain the situation under control; and (4) to find a permanent solution to the problem. According to Kanse’s categorization, this study designed question items for the construct of proactivity in miniature design.

SI: A measure of SI was adapted based on the definition proposed by Hidi and Renninger (2006). SI refers to focused attention and the affective reaction in the moment to environmental stimuli. Accordingly, triggered SI items were designed to identify the perception of interest at the beginning of joining PowerTech. Maintained interest items were designed to identify the perception of interest in the national PowerTech contest.

Perceived Learning Values: In a complex task, mental processes include the integration of multiple pieces of information to discern the best course of action (Dixon & Christoff, 2014). While project making processes enhance the probability of involving students and engaging them with the learning materials (Shen, Chen, & Guan, 2007), they can also enhance students' attitudes towards future meaningful learning (Hulleman & Harackiewicz, 2009). Hong, Hwang, Szeto, Tai, and Tsai (2016) indicated that by joining a science and technology contest, students' knowledge can be enriched. Referring to the above excerpts, this study designed questionnaire items to test perceived learning values.

Results

The analysis was conducted in two steps. First, a suitability analysis was applied to examine triggered and maintained interest. Second, first-order Confirmatory Factor Analysis (CFA) was applied to analyze the items. Third, Statistical Package for the Social Sciences (SPSS) 22.0 was used to test the reliability and validity of the measuring questionnaire. Finally, AMOS 20 software was adapted to test the model fit and path modeling over covariance-based Structural Equation Modeling (SEM) analysis.

Correlation Analysis of Triggered Interest and Maintained Interest

As the data collection in relation to triggered and maintained interest occurred at different points in time, the data's suitability for SEM needs to be examined. This study used paired-sample *t*-test to test the difference between two SIs, and found that there was no significant difference between triggered interest and maintained interest ($t = .50$, $p > .05$). The result revealed that the different time points of the data collection did not sway the participants' interest. Moreover, the correlation coefficient between triggered interest and maintained interest was .72 ($p < .001$), the correlation coefficient between proactivity and triggered interest was .57 ($p < .001$), the correlation coefficient between proactivity and maintained interest was .58 ($p < .001$), the correlation coefficient between perceived learning values and proactivity was .57 ($p < .01$), the correlation coefficient between perceived learning values and triggered interest was .65 ($p < .001$), the correlation coefficient between perceived learning values and maintained interest was .67 ($p < .001$). Thus, the results revealed that these two SI factors were suitable for the structure of the model between the four factors.

Item Analysis

The original items in each construct were subjected to first-order CFA to refine the number of items in each construct. According to the principles of a parsimonious model and an independent residual, it is needed to reduce the number of items in each construct. Table 1 showed the values of

χ^2/df of the constructs were all less than the threshold value of 5. In addition, the values of Goodness of Fix Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) were above the threshold value of .80, and Root Mean Square Error of Approximation (RMSEA) values were less than the threshold value of .08, which indicates there was a good fit in each construct (Doll, Xia, & Torkzadeh, 1994; Hu & Bentler, 1999). The results revealed that items for proactivity were reduced from 6 to 5, the items for triggered interest were reduced from 5 to 4, the items for maintained interest were not reduced, and the items for perceived learning values were reduced from 6 to 4.

Table 1

The First-Order of CFA

Measurement Index	Threshold	Proactivity	Triggered Interest	Maintained Interest	Perceived Learning Values
χ^2	–	2.67	3.28	5.77	2.07
df	–	5	2	5	2
χ^2/df	< 5	.53	1.64	1.15	.96
RMSEA	< .08	.00	.06	.04	.00
GFI	> .80	.96	.95	.94	.97
AGFI	> .80	.98	.96	.97	.96

Reliability and Validity Analysis

First, the reliability can be evaluated using internal consistency and Composite Reliability (CR). Table 2 showed the Cronbach’s α values, which were above .81. According to Hancock and Mueller (2013), a Cronbach’s α value above .6 indicates an acceptable level of reliability. Moreover, to determine the CR of the constructs, all the CR values were above .83, which surpassed the suggested threshold value of .7 (Hair, Hult, Ringle, & Sarstedt, 2016).

Second, the convergent validity in this study verified whether: (1) the Average Variance-Extracted (AVE) values were greater than .5 (Fornell & Larcker, 1981); and (2) the Factor Loadings (FL) of all the items were significant and greater than .5. If these conditions were met, it indicated acceptable construct validity (Hair et al., 2016). Table 2 showed the AVE values were above .57, and the FL values were above .72; therefore, all conditions were met, indicating that there was acceptable convergent validity.

Table 2

Reliability and Validity Analysis

Items of Each Construct	*M*	*SD*	FL	*t*-value
Proactivity: CR = .87, AVE = .57, α = .81				
1. Before I start to create a miniature, I attempt to think of as many details as possible	3.58	.88	.73	8.24
2. When I am designing a miniature, I think of how to prevent things from becoming out of control	3.43	.90	.74	7.73
3. Before something goes wrong in the miniature design process, I attempt to find the amount, scope and impact of error consequences	3.30	.91	.80	7.78
4. Before something goes wrong in the miniature design process, I will attempt to find a temporal solution and maintain control of the situation	3.18	.92	.78	8.66
5. Before something goes wrong in the miniature design process, I attempt to find a permanent solution to the problem	3.09	.97	.73	8.40
Triggered Interest: CR = .89, AVE = .67, α = .88				
1. The first time I designed miniatures, I enjoyed the hands-on making process	4.07	.96	.77	12.85
2. The first time I designed miniatures, I found hands-on making extremely fun	4.29	.94	.86	11.03
3. The first time I designed miniatures, I felt curious about how animals move	4.19	.96	.87	14.78
4. The first time I designed miniatures, I was very interested in hands-on making	4.27	.98	.84	13.62
Maintained Interest: CR = .94, AVE = .75, α = .91				
1. Although I have redesigned the miniatures several times, I am still very excited to design again	4.15	.96	.89	17.26
2. Although I have redesigned the miniatures several times, I am still very happy to design again	4.22	.94	.85	19.27
3. Although I have redesigned the miniatures several times, I still look forward to designing	4.25	.93	.91	20.34
4. Although I have redesigned the miniatures several times, I am still very engaged in the designing process	4.18	.92	.81	14.74
5. Although I have redesigned the miniatures several times, I still feel like it is a new and fresh experience when I have to design miniatures	4.13	.96	.80	13.49

(Continue)

Table 2

Reliability and Validity Analysis (continue)

Items of Each Construct	*M*	*SD*	FL	*t*-value
Perceived Learning Values: CR = .83, AVE = .56, α = .83				
1. In creating miniatures for the contest, I learned advanced science knowledge to solve problems	4.11	.86	.79	9.72
2. In creating miniatures for the contest, I believe the knowledge I learned is meaningful	4.11	.97	.78	9.58
3. In creating miniatures for the contest, my learning is extended beyond the area of science	3.69	.93	.74	9.63
4. In creating miniatures for the contest, I engaged in deeper learning	4.22	.86	.71	9.05

To establish discriminant validity, the square root of every AVE value must be determined. The rule states that the square root of the AVE of each construct should be significantly larger than the correlation of the specific construct with any of the other constructs (Chin, 1998). Table 3 showed the results of the discriminant validity analysis, and on the diagonal parts, the square root of every AVE value was inserted to compare it with the other correlation coefficients. The results indicated that the square root of every AVE value is above the correlation coefficient of the other constructs, which shows discriminant validity exists in the research constructs.

Table 3

Discriminant Validity Analysis

	Proactivity	Triggered Interest	Maintained Interest	Perceived Learning Values
Proactivity	.75			
Triggered Interest	.57***	.82		
Maintained Interest	.58***	.72***	.87	
Perceived Learning Values	.57***	.65***	.67***	.75

****p* < .001.

Model Fit Analysis

According to Hair et al. (2016), the model fit indexes for the absolute fit measures include the Chi-square, RMSEA, GFI, and AGFI. The overall absolute fit measures in this research were χ^2=239.64; the degree of freedom was 130, which indicates χ^2/df = 1.84, and a ratio of less than 3 is considered a good fit (Kline, 2005). For RMSEA, a threshold value of RMSEA less than .08

indicates a good fit (Hu & Bentler, 1999), the *p* of close fit (PCLOSE) is the probability that RMSEA is significantly greater than zero, a PCLOSE value greater than .05 indicates a good fit (Byrne, 2001). For GFI, Doll et al. (1994) indicated a threshold value of GFI above .80 is acceptable. In addition, for AGFI, MacCallum and Hong (1997) suggested a threshold value above .80 is acceptable. The RMSEA was .06, PCLOSE was .08, GFI was .88, and AGFI was .84, which indicated acceptable fit. The values of model fit indexes greater than .90 are considered a good fit (Schumacker & Lomax, 2004). Ullman (2001) suggested the standard could be loosened to greater than .80. The incremental fit measures in this research were NFI = .90, NNFI = .94, IFI = .95, CFI = .95 and RFI = .87. The parsimonious adjusted measures include parsimony comparative fit index (PCFI), PCFI parsimonious normed fit index (PNFI) and parsimonious goodness of fit index (PGFI). According to Mulaik (2009), PCFI, PNFI and PGFI should be above .5 for a good model fit. The results of this study were as follows: PCFI = .81, PNFI = .77 and PGFI = .67. Overall, according to Hair et al. (2016), the model fit indexes above showed that the model of this research was acceptable.

Path Analysis

SEM can be used to verify the research model (Hershberger, 2003). Table 4 showed the results of direct and indirect effect by utilizing the bootstrapping method. As for direct effect, proactivity was significantly correlated to triggered interest (β = .64, t = 6.95, p < .001); proactivity was significantly correlated to maintained interest (β = .28, t = 3.52, p < .001); triggered interest was significantly correlated to maintained interest (β = .59, t = 7.25, p < .001); triggered interest was significantly correlated to perceived learning values (β = .36, t = 3.36, p < .001); maintained interest was significantly correlated to perceived learning values (β = .47, t = 4.39, p < .001). Further, each 95% confidence interval (CI) did not include zero, which revealed direct effect existed in this research model.

Figure 3 showed the results of the path relationship among the hypotheses, and H1 through H5 were supported. In addition, the explanation power for proactivity on triggered interest was 41%, and the effect size (f^2) was .69; the explanation power for proactivity and triggered interest on maintained interest was 61%, and the f^2 was .51; the explanation power for proactivity, triggered interest and maintained interest on perceived learning values was 64%, and the f^2 was .08. The R^2 values were more than the recommended threshold value of 10% proposed by Falk and Miller (1992), and the effect sizes were strong on triggered interest and maintained interest but weak on

Table 4

The Results of Direct Effect by Using Bootstrapping Method

	Proactivity		Triggered Interest		Maintained Interest	
	β	95% CI	β	95% CI	β	95% CI
Triggered Interest	.64***	[.52, .74]	–	–	–	–
Maintained Interest	.28***	[.13, .42]	.59***	[.45, .71]	–	–
Perceived Learning Values	–	–	.36***	[.14, .55]	.47***	[.27, .65]

***p < .001.

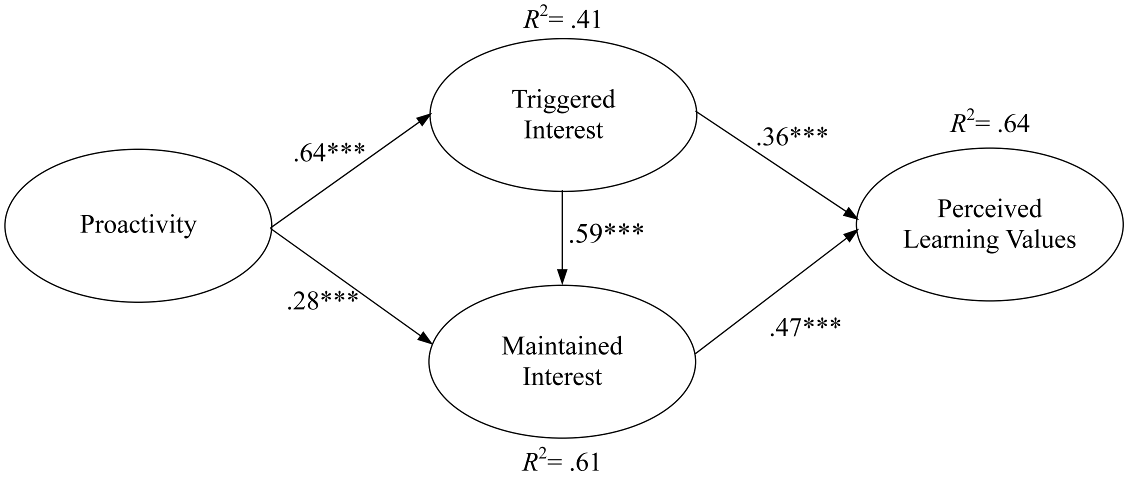

Figure 3. Verification of Research Model

***p < .001.

perceived learning values (Cohen, 1988). Therefore, all variables of this research had acceptable predictive power (Hair et al., 2016).

Discussion

Previous studies agree on the importance and effectiveness of hands-on activities as a means to encourage students to study Science, Technology, Engineering and Mathematics (STEM) (Christensen, Knezek, & Tyler-Wood, 2014). The competitive nature of PowerTech demands hands-on making by restricting the time and materials for miniature making. Thus, whether students' proactivity and SI were important to their perceived learning values of attending a hands-on making contest was explored. Hypotheses 1 and 2 proposed to test the correlation between proactive thinking and two types of SI; results indicated they were positively correlated. This result is supported by Renninger and Hidi (2002), who found that learning interest enables a person to persevere, take risks and work resourcefully to resolve difficulties and problems that may arise despite feelings of frustration and failure. Moreover, in hands-on making, students with a high level of proactivity can avoid the potential failures of spending extra time and incurring opportunity costs (Rochlin et al., 2014). SI from doing the task may prevent minor things from going wrong and affect the chance of winning (Hidi et al., 2004).

Hypothesis 3 proposed to test the correlation between triggered interest and maintained interest, the results of which showed the correlation to be positive. It is likely that one with a high level of triggered interest has a high level of maintained interest and this positive correlation was consistent with the results of the study. This result is also consistent with other studies. For example, Ainley (2006) posited that once triggered, SI needs to be maintained for learning to occur. With the same argument, Harackiewicz, Durik, Barron, Linnenbrink-Garcia, and Tauer (2008) claimed that once SI is triggered, it could move into the second phase of interest development and be maintained if the task continues to be meaningful for the students. Whether participants can maintain SI is very important to having them continuously engage in the designing-making-modifying cycle of PowerTech.

Hypotheses 4 and 5 proposed to test the correlation between two types of SI and learners' perceived values of hands-on making and learning. The results showed that they were positively correlated. In relation to the trigger-maintenance of interest, Rotgans and Schmidt (2012) noted that there is no need for interest to increase with increasing knowledge gains and that maintaining a sufficiently high level of SI is all that is needed for learning to occur. Dewey (1913) proposed that triggering interest could be achieved by presenting various cognitive and sensory stimuli, whereas maintaining it could best be achieved by involving students in meaningful activities that empower them in learning. Thus, this study showed that if participants reported a high level of triggered interest; they would have correspondingly high perceived learning values (t = 3.36, p < .001). However, the value of the coefficient between triggered interest and perceived learning values was β = .36, which was less than the value of the coefficient between maintained interest and perceived learning values (β = .47). This result showed that maintained SI influenced the depth and breadth of knowledge that students gain when they participated in the PowerTech competition.

Conclusion

This study's findings suggest that proactivity is an important construct, which is relevant to the study of hands-on making projects. This study showed that proactivity can explain how individuals' SIs may differ when participating in a hands-on science and technology contest. The findings from this study have an important theoretical implication. This study provides support for perspectives that consider the link between personal proactivity theory and SI theory. By marrying proactivity to interest, which is triggered and maintained during the course of practicing and engaging in a hands-on science and technology contest such as PowerTech, this study showed how the component of personal proactivity can help explain different SIs when evaluating learning behaviors.

One practical implication of this study is to help STEM educators to recognize that students' proactivity may alter the importance they place on hands-on making contests. The findings suggest that by joining PowerTech, students with varying levels of proactivity positively triggered and maintained their interest in hands-on making. Individuals who perceived high learning values experienced meaningful learning through hands-on making.

Limitation and Future Study

Loibl and Rummel (2014) emphasized the importance of understanding that initial failure can be productive prior to successful problem solving. In technological project design, female students focused more on details to prevent product failure than the male students. In addition, Ainley, Hillman, and Hidi (2002) found that boys experienced triggered interest more than girls in the arousal of interest phase, but with literary texts, girls maintained interest longer than boys. Gender difference was not examined in this research. Future studies may compare gender differences in proactivity, SI and perceived learning values in the context of hands-on making.

Several theories of achievement motivation have proposed that a challenge, (defined as task difficulty that is matched to or slightly beyond one's ability), increases motivation (Csikszentmihalyi, 1991; Wigfield & Eccles, 2002) and interest (Fulmer & Tulis, 2013). This study was limited to investigating how students' SI was affected by hours spent on making PowerTech miniatures while participating in PowerTech. To understand the correlation between hours spent and SI, future studies can examine students with achievement motivation in hands-on tasks and look at how the number of hours they spent per week on designing and redesigning miniatures affected their triggered and maintained interest.

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正向心態對初始興趣、維持興趣及動手做科學創作競賽學習價值之相關研究

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摘要

本研究旨在探討正向心態對初始興趣、維持興趣及動手做科學創作競賽學習價值之相關。本研究之研究樣本為動手做科技創作競賽之參與學生，該競賽要求學生須在早上設計及製作三隻仿生機械獸，並在下午進行接力與拔河競賽。本研究回收有效樣本 197 份，以結構方程模式進行驗證性因素分析與模型分析。研究對象有 135 位男學生（68.5%）和 62 位女學生（31.5%），九年級學生有 91 位（46.2%）和六年級學生有 106 位（53.8%）。結果顯示正向心態對初始興趣、維持興趣及動手做科學創作競賽學習價值呈顯著正相關。路徑係數分別為 .64、 .28、 .59、 .36 與 .47，且具高效果量。研究結果指出，正向心態有助於個體初始興趣及維持興趣感受之產生，進而提升動手做科學創作競賽之學習價值。

關鍵詞：動手做、維持興趣、學習價值、正向心態、初始興趣

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