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CONTRIBUTION OF SCIENTIFIC CREATIVITY AND AFFECTIVE FACTORS TOWARDS STUDENTS' PHYSICS ACHIEVEMENT: A STRUCTURAL EQUATION MODELING ANALYSIS

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Abstract

Physics achievement at the secondary school is not encouraging, and physics teachers are not keen to implement creativity-based learning. This affects students' involvement in physics learning, plus, the affective aspects of students not given attention because it is considered not to influence students' examination grades. The main purpose of this research was to analyses the contribution of creativity domain physics, general creativity and affective factors towards students' physics achievement by using structural equation modeling analysis. The research employed a survey design with a data collection method using tests and questionnaires among 400 form four students in the public secondary school in Johor. The data were analysed using Statistical Packages for Social Sciences (SPSS) and Analysis of Moments Structures (AMOS) version 21. The structural equation modeling results showed that scientific creativity and divergent thinking directly affect physics achievement. In contrast, general creativity and affective factors affect indirectly. The findings also showed that the strongest relationships were between physics divergent thinking and scientific creativity, scientific creativity and physics achievement and between intrinsic motivation and attitude towards physics. The study's implication suggests that vigorous effort needs to be focused on developing physics divergent thinking and scientific creativity, as these factors are the most influential and directly related to physics achievement. It is equally important that the affective factors, namely students' self-efficacy and students' attitudes towards physics, are emphasized. These factors significantly affect students' physics divergent thinking, which would eventually lead to better physics achievement.

Keywords: Physics achievement, scientific creativity, creativity drawing products, attitude towards physics, self-efficacy, intrinsic motivation.

INTRODUCTION

One of the challenges in secondary school education is providing high-quality students with excellent academic achievement [1, 2]. The achievement of Malaysian form four students in physics is not encouraging because several physics topics are considered difficult by students, such as Introduction to physics and Force and Motion [3, 4]. Conventional learning, such as teachers providing step-by-step problem-solving methods, is no longer effective in conceptual understanding and physics problem-solving skills [5, 4]. Nevertheless, in reality, physics students still practice conventional learning, contributing to the decline in physics achievement [4].

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Creativity is in the top three most demand skills needed to endure the 4th Industrial Revolution (4IR) since it is a cognitive skill that is more important than complex information processing, understanding, advanced literacy and writing skills [6]. Creativity is a necessary skill in future careers. Fostering creative thinking is an initiative to change ineffective teaching and learning (T&L) practices [7, 8].

Physics is the most suitable medium for cultivating creative thinking skills and many researchers have agreed that creativity can influence physics achievement [9, 10]. However, thinking creatively is not cultured by most physics teachers while students do not have the opportunity to generate diverse and unique ideas in the classroom [11, 12]. Sawyer supported this statement, stating that the creative thinking culture is not welcome in the school and is more pronounced in Asian countries, including Malaysia [13]. One of the reasons, creativity is not welcome and teachers are not confident in the effectiveness of such creative activities in helping students improve achievement grades [14].

Many creativity studies have been conducted, and most studies involve only one type of creativity in one study. Through the reading of past studies, there have been research of constructing models or theoretical frameworks that apply general creativity only and do not integrate with scientific creativity even though the field of study is in science [12]. Thus, there is a need to study more than two types of creativity in a research. This gives an idea to simultaneously test different type of creativity such as general creativity and creativity domain physics to identify its contribution to students' physics achievement.

There is a need to collectively and holistically integrate creativity with affective characteristics to determine its influence on physics achievement [15]. This is because a lack of specific theory or model looks at the holistic interaction between general creativity and creativity in physics, with affective characteristics such as attitudes towards physics, self-efficacy, and intrinsic motivation towards student physics achievement at the secondary school level. The model constructed by Son (2009) was not studied in the context of physics education [16]. While Bloom's taxonomy (1956) and Amabile's Specific Domain Creativity Theory (1983) have combined cognitive and affective components but need to be reconceived as needed based on issues and problems that arise [17, 18].

Based on the gaps that have been identified, it can be concluded that a model contains information on the interaction between factors that contribute to the physics achievement that involves integration between more than one concept of creativity and affective need to be studied. Thus, a study was conducted to examine the contribution of these cognitive and affective factors simultaneously and holistically to see its influence on the physics achievement of form four public secondary school students in Malaysia by using the Structural Equation Model (SEM-AMOS) application.

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Research Objectives

The main purpose of this study was to verify the structural equation hypothetical model to adequately fit the research data and analyses the contribution and strength of relationships between variables in the model. The predictor factors studied for their contribution to physics achievement are general creativity of drawing products (TCT-DP), scientific creativity in physics (SCP), divergent thinking in physics (DTP), and affective factors, namely attitude towards physics (ATP), self-efficacy (SE) and intrinsic motivation (IM).

Literature Review

The decline in physics achievement has attracted the interest of many researchers to examine the factors that influence student achievement. According to Napitupulu et al. (2018), cognitive factors are a key focus that needs to be developed if teachers want physics students to excel in their learning and achievement [19]. Nevertheless, to develop cognitive aspects, studies are stating that affective factors are the aspects that play the most important role as these factors influence the internal aspects of students that motivate students to perform mental functions such as thinking [19]. Thus, this research focused on aspects of scientific creativity, divergent thinking in physics and general creativity to represent cognitive factors and attitudes towards physics, intrinsic motivation and self-efficacy to represent affective factors to study their contribution to physics achievement. These factors were analysed simultaneously using structural equation model analysis of moment structures (SEM-AMOS) statistical software.

There are a lot of studies have been conducted and many theories have been confirmed empirically to prove that the freedom of students to think creatively can affect student achievement [7, 9, 10, 11, 12, 16, 20]. However, most creativity studies involve only one approach of creativity. For example, Theurer, Berner & Lipowsky (2016) and Roke & Kalis (2015) used Test of Creative Thinking-Drawing Product (TCT-DP) while Siti Rafiah (2008) and Fauziah, Coll & Suriani (2014) used Torrance Tests of Creative Thinking (TTCT) to study the effect of general creativity towards academic achievement [21, 10, 22, and 23].

However, due to development in the study of creativity, researchers expanded the focus from general creativity to creativity domain specific, also known as scientific creativity. For example, Liang (2002) and Raj Saxena (2016) did research related to scientific creativity in the domain of science while Park (2012), Rabari (2011) and Razip (2014) focused their research in scientific creativity in the domain of physics [9, 12, 24, 25, and 26]. These studies of creativity with various approaches, whether general creativity or scientific creativity, have raised questions about what type of creativity approaches influence student achievement according to specific fields such as physics. This is because the approaches and concepts of general creativity and scientific creativity are different, so their influence on an achievement should also be different.

A meta-analysis study by Chang et al. (2017) concluded that studies to build models using Structural Equation Modeling (SEM) analysis involving creativity and academic achievement have been widely available [15]. Still, most models do not integrate cognitive with affective

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aspects collectively and holistically. The role of affective aspects is important to encourage students to think creatively and learning actively [27]. The reality now is that physics students are less motivated and show weak and declining attitudes and self-efficacy [27, 28, 29, 30].

According to LaForce, Noble and Blackwell (2017), affective aspects such as motivation, self-efficacy and attitude are essential for continuously aim good academic achievement [30]. These affective traits can influence students' acceptance to continue their effort in mastering complex scientific knowledge. The findings of the influence of different affective traits raise a question of how interactions occur between intrinsic motivation, self-efficacy, attitudes toward creativity and physics achievement.

Conceptual Framework

This research intends to test the relationship among constructs that are modelled into a conceptual framework. A conceptual framework was constructed from two existing theories and one model that have been widely used namely Theory Creativity Domain Specific (Amabile, 1983), Bloom's Taxonomy Learning Domain (1956) and Model of Scientific Creativity (Son 2009) [16, 17, 18]. The cause-and-effect relationship between the two variables was also constructed based on some models and findings from previous studies [8, 12, 16, 31, 32, 33, 34,].

Bloom's Taxonomy explained that meaningful learning involves cognitive abilities accompanied by affective and psychomotor domains [17]. While the Scientific Creativity Model that analyse by Son (2009) using SEM-AMOS and built based on Amabile's Model of Creativity Domain-Specific (Amabile, 1983) contains cognitive factors (general creativity and creativity domain-specific) and affective factors (intrinsic motivation and attitude) [16, 18]. Another affective factor, self-efficacy, was chosen because a systematic review of several structural models by Bandura (1993) has shown the importance of self-efficacy towards academic achievement [32]. This adds value to the hypothetical model to be tested. Figure 1 shows the conceptual framework that has been restructured based on the theories and models discussed above.

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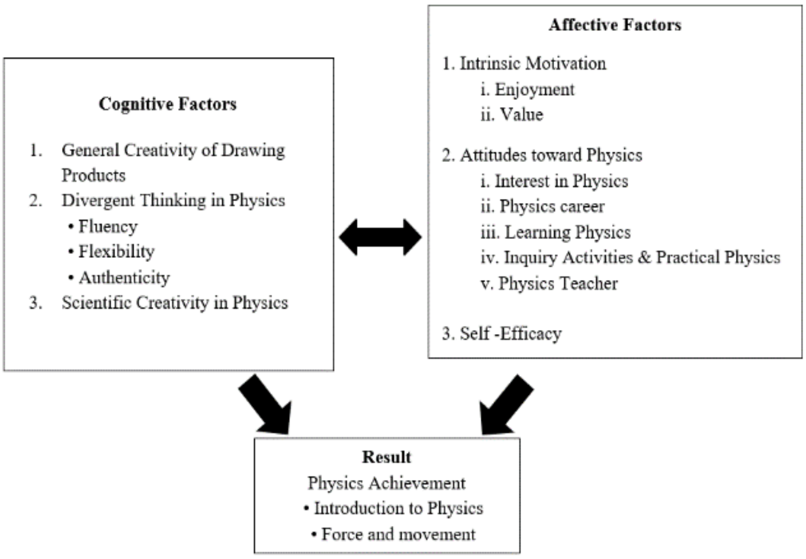

Fig 1: Conceptual framework

The conceptual framework has been divided into three parts, cognitive factors, affective factors and result. For cognitive factors, there are three concepts of creativity selected to be studied; general creativity of drawing products (TCT-DP), DTP and SCP. Three subconstructs represent DTP: fluency, flexibility, and originality [33, 35]. For affective factors, there are SE, IM and ATP. There are two indicators used to measure IM, namely enjoyment and value [36, 29], while five indicators are used to measure ATP, namely interest in physics, physics career, learning physics, inquiry activities and practical physics and physics teachers [37].

RESEARCH HYPOTHESES

Figure 2 shows a hypothetical model of the contribution of cognitive factors and affective factors towards physics achievement. The model was constructed by using the Structural Equation Modeling (SEM-AMOS) path-analysis diagram.

In this hypothetical model there were existence of mediator role. The arrangement of these mediators is based on theories, models and previous findings. Amabile's Model of Creativity Domain-Specific and Scientific Creativity Model by Son stated that affective factors such as intrinsic motivation and attitude can play a direct or indirect role, which requires the mediator to affect cognitive function [18, 16]. Scientific Creativity Model by Son also gives the idea that general creativity and scientific creativity can influence achievement indirectly. However, the role of mediator is not a main focus in this research and is not discussed.

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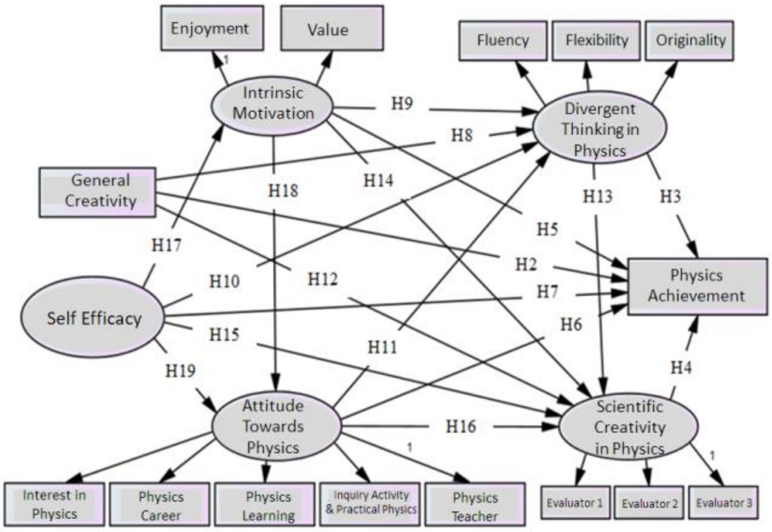

Fig 2: Hypothetical Model

Below is a list of 19 hypotheses that were tested.

Hypothesis 1:

The structural equation model fits adequately to the research data.

Hypothesis 2:

General creativity of drawing products (TCTDP) has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 3:

Divergent thinking in physics has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 4:

Scientific creativity in physics has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 5:

Intrinsic motivation has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 6:

Attitude towards physics has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 7:

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Self-efficacy has a positive and significant direct effect practically and statistically on physics achievement.

Hypothesis 8:

General creativity of drawing products (TCTDP) has a positive and significant direct effect practically and statistically on divergent thinking in physics.

Hypothesis 9:

Intrinsic motivation has a positive and significant direct effect practically and statistically on divergent thinking in physics.

Hypothesis 10:

Self-efficacy has a positive and significant direct effect practically and statistically on divergent thinking in physics.

Hypothesis s 11:

Attitude towards physics has a positive and significant direct effect practically and statistically on divergent thinking in physics.

Hypothesis 12:

General creativity of drawing products (TCTDP) has a positive and significant direct effect practically and statistically on scientific creativity in physics

Hypothesis 13:

Divergent thinking in physics has a positive and significant direct effect practically and statistically on scientific creativity in physics.

Hypothesis 14:

Intrinsic motivation has a positive and significant direct effect practically and statistically on scientific creativity in physics.

Hypothesis 15:

Self-efficacy has a positive and significant direct effect practically and statistically on scientific creativity in physics.

Hypothesis 16:

Attitude towards physics has a positive and significant direct effect practically and statistically on scientific creativity in physics.

Hypothesis 17:

Self-efficacy has a positive and significant direct effect practically and statistically on intrinsic motivation.

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Hypothesis 18:

Intrinsic motivation has a positive and significant direct effect practically and statistically on attitude towards physics.

Hypothesis 19:

Self-efficacy has a positive and significant direct effect practically and statistically on attitude towards physics.

Methodology

This study is a descriptive quantitative study that uses a survey research design. The population consists of 10,680 form four students (16 years old) in the public secondary school in Johor, Malaysia. Based on the population, a total of 400 students were selected as the research sample using three combinations of sampling techniques, proportionate stratified random sampling (determination of districts in Johor), simple random sampling procedure (school selection) and cluster sampling procedure (class selection).

Briefly, the school is divided into four zones in the state of Johor, namely the southern zone (5267 students, 49.32%), the northern zone (2360 students, 22.10%), the western zone (2250 students, 21.06%) and the eastern zone (803 people. students, 7.52%). The percentage of students in each zone was identified to ensure that the number of samples in each zone was selected balanced according to the percentage rate. The detail number of samples discussed in the Profile of Respondent (Result).

The number of samples is determined based on the suggestions made by Hair et al. (2010), Kline (2011) and Yuan et al. (2010) [38, 39, 40]. All students in the selected class completed all the instruments given to them. Form four students were selected because physics was first studied by form four students at the school level. In addition, topics that are found to be difficult to learn are from the form four syllabus. Therefore, this population is targeted because the factors that influence physics achievement should be identified from the early stage of physics learning.

Research Instruments

There are seven instruments used, namely Physics Achievement Test (PAT), Test of Creative Thinking Drawing Product (TCT-DP), Divergent Thinking in Physics Test (DTPT), Scientific Creativity in Physics Test (SCPT), Self-Efficacy Questionnaire (SEQ), Intrinsic Motivation Questionnaire (IMQ) and Attitudes Towards Physics Questionnaire (ATPQ).

Physics Achievement Test (PAT)

PAT consists of two parts. Part A containing 30 objective questions covering the topic of Introduction to Physics and Force and Motion. Part B is a written practical test related to the topic of Inertia.

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Test of Creative Thinking–Drawing Product (TCT-DP)

TCT-DP was designed by Urban and Jellen (1996) [41]. TCT-DP is an effective drawing-based instrument for measuring creative ability [42]. The TCT-DP is measured through scores obtained from fourteen criteria. The criteria in TCT-DP represent the competence to generate exceptional figures with a single theme or give meaning to the result of the creative drawing as a whole [41].

Divergent Thinking in Physics Test (DTPT)

DTPT is an open-ended test adapted from Hu and Adey (2002), Mohamed (2006), Razip (2014) and Alrubaie & Daniel (2014) [9, 34, 43, 44]. There are two questions in the DTPT. First, students are asked to list as many scientific observations as possible based on the given pictures in the first question. The observations requested are related to the causes and effects of bicycle and car accidents. In the second question, students are asked to list as many solutions as possible to the observations that have been made in the first question. Scores are based on three characteristics of divergent thinking that are fluency, flexibility and originality. Fluency is the number of scientific answers/ideas successfully identified by respondents. Flexibility is an approach to see the variety of categories of answers given by respondents. Originality is measured based on the generation of new ideas that have not been proposed or designed by other respondents [12, 34].

Scientific Creativity in Physics Test (SCPT)

In the SCPT, only have one item that requires students to design a product for the solution proposed in the DTPT. Scientific creativity scores are given based on a scoring rubric that has been constructed using the Consensual Assessment Technique (CAT) introduced by Amabile (1996) [45].

Self-Efficacy Questionnaire (SEQ)

SEQ was adapted from the Physics Self-Efficacy Scale (PSES) constructed by Tezer and Asiksoy (2015) [46]. After undergoing confirmatory factor analysis (EFA), the SEQ was represented by five items with a seven-point Likert scale.

Intrinsic Motivation Questionnaire (IMQ)

The IMQ was adapted from the Intrinsic Motivation Inventory (IMQ) constructed by McAuley et al. (1989) [47]. After undergoing an EFA, the IMQ contained two subconstructs with a total of 10 items. The subconstructs included enjoyment (5 items) and values (5 items) with a seven-point Likert scale.

Attitudes towards Physics Questionnaire (ATPQ)

ATPQ was adapted from the Attitude Towards Physics questionnaire by Ovute et al. (2015), which was initially adapted from the Test of Science Related Attitude (TOSRA) by Fraser (1981) [48, 49]. After undergoing an EFA, the ATPQ contains five subconstructs totalling 23

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items namely interest in physics (3 items), physics career (5 items), physics learning (5 items), inquiry activities and practical physics (5 items) and physics teacher (5 items).

Data Analysis

All data collected through seven research instruments have been saved in SPSS software before being analysed using SEM-AMOS version 21. SEM-AMOS has the advantage of testing relationships between complex and dynamic variables simultaneously that other statistical analysis software cannot do [38]. For data analysis, the researcher refers to two modelling steps that have been proposed by Chua (2009) and Kline (2011), i) testing the measurement model for validity and reliability and ii) testing the structural model to test the hypotheses [39, 50].

i) Validity and Reliability of Measurement Model

Three criteria must be met before analysing the structural model: unidimensionality, validity, and reliability. Pooled CFA is implemented to achieve these three criteria. The items with a loading factor, λ <0.5, are eliminated from the construct to achieve the reliability and validity indexes. Next, the measurement model is evaluated statistically using fitness indexes to ensure that the model fits adequately with the research data. Table 1 shows the indicators for obtaining unidimensionality, validity and reliability.

Table 1: Indicator of unidimensionality, validity dan reliability

Criteria	Indicator
Unidimensional	When the loading factor > 0.6
Validity	Convergent validity • Average Variance Extracted (AVE) values > 0.5 Construct validity • Fitness indexes Chisq p > 0.05 RMSEA< 0.80 GFI > 0.90 AGFI > 0.90 CFI > 0.90 TLI > 0.90 Chisq/df < 5.0 Discriminant validity • Correlation between variables
Reliability	Inner Consistency • Cronbach alpha (CA) > 0.7 Construct reliability • CR > 0.6 Average Variance Extracted • AVE > 0.5

In this study, there are three categories of fitness indexes, i) absolute fit, ii) incremental fit and iii) parsimonious fit. Absolute fit consists of Root Mean Square of Error Approximation (RMSEA) and Goodness of Fit Index (GFI) while incremental fit consists of Adjusted Goodness of Fit (AGFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Normed Fit Index (NFI). Parsimonious fit consists of Chi Square/ Degree of Freedom (Chi-Square/ df). GFI, CFI, TLI, NFI value should be equal to or greater than 0.90 indicates a good fit while a

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good fit value for Chi-Square/df is less than 0.3. RMSEA value below 0.10 indicates a good fit and below 0.05 is deemed a very good fit (38, 51, 52]. One index that achieves the level of acceptance for each category is sufficient to allow for the next step to test the hypotheses from the structural model.

Structural Model

After a pooled CFA process, a structural model was formed and analysed to eliminate items and obtain high validity and reliability. There are four path coefficients observed in the dynamic analysis between the variables studied. The coefficients are standard estimates or standard regression weights (β), standard error (S.E), critical ratio (C.R) and significant value (p). The necessary coefficients taken into account for accepting or rejecting the hypothesis are β and p.

The contribution value of β can be interpreted into three levels of contribution, i) small contribution for value β smaller than 0.10, ii) moderate contribution level for value β 0.10 to 0.50 and iii) high contribution level for value β greater than 0.50 [52]. Small ($\beta < 0.10$) and negative contribution levels were considered not practically significant predictors of physics achievement. Thus, β smaller than 0.10 and negative will not be accepted, thus rejecting the hypothesis even if the p-value is significant. The value of p is considered significant when p is smaller than 0.05. In other words, the significant values for hypothesis testing were $p < 0.05$ and $\beta > 0.10$.

Results

The distribution of respondents consists of 31 students from Kota Tinggi district, 103 from Johor Bahru, 90 from Pasir Gudang, 84 from Batu Pahat, 31 from Tangkak and 61 from Muar. Female respondents were 246 compared to 154 male respondents. Respondents representing the Malays are the highest with 234, followed by 102 Chinese, 55 Indians and 9 students from other race. The profiles of the respondents are summarized in Table 2.

Table 2: Profile of respondents

Demographic	Zone	District	N=400	Percentage (%)
Location (District in Johor)	East	Kota Tinggi	31	7.8
	South	Johor Bahru	103	25.8
		Pasir Gudang	90	22.5
	West	Batu Pahat	84	21.0
	North	Tangkak	31	7.8
		Muar	61	15.3
Gender		Male	154	38.5
		Female	246	61.5
Race		Malay	234	58.5
		Chinese	102	25.5
		Indian	55	13.8
		Other	9	2.3

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Pooled CFA: Validity and Reliability of Measurement Model

There are seven constructs studied, two formative constructs (using test scores) and five reflective constructs (using scale measurement with indicators and have items). Only reflective constructs (SE, IM ATP, DTP, and SCP) were involved for the pooled CFA analysis while formative constructs (PA and TCT-DP) were not involved. Formative constructs were not analysed along with reflective constructs in the pooled CFA analysis because formative constructs were measured through scores with no indicators and items to be eliminated to obtain a good fit index [52]. Figure 3 shows the pooled CFA analysis and Table 3 shows the pooled CFA results. Table 4 shows the fitness indexes from the pooled CFA analysis.

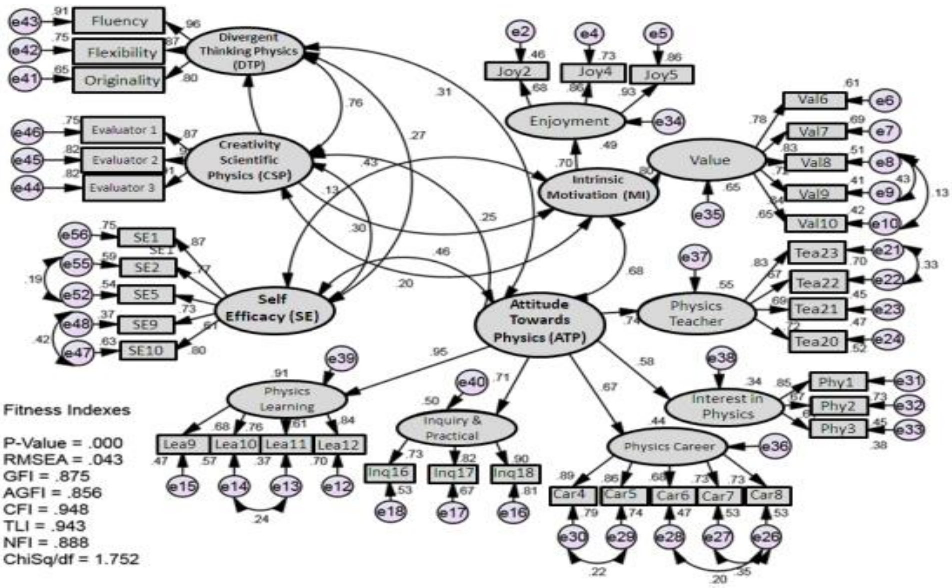

Fig 3: Pooled CFA analyses

Table 3: Pooled CFA results

	IM	ATP	SE	DTP	SCP	CR ≥ 0.6	AVE ≥ 0.5	CA
IM	**.755**					0.725	0.570	0.868
ATP	.685	**.742**				0.856	0.550	0.909
SE	.425	.457	**.760**			0.871	0.577	0.875
DTP	.135	.309	.272	**.877**		0.909	0.770	0.890
SCP	.201	.248	.297	.763	**.892**	0.921	0.796	0.920

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Table 4: Fitness indexes of pooled CFA analysis

Goodness of Fit Index	Category	Level	Values
RMSEA	*Absolute fit*	≤ 0.80	0.043
CFI	*Incremental fit*	≥ 0.90	0.948
TLI		≥ 0.90	0.943
Chis/df	*Parsimonious fit*	≤ 3.0	2.409

From the result in Table 3 and Table 4, it can be concluded that there is a significant fit for the studied variables in the model and allows the next step to be done. The next step is analysing the structural equation model to identify the contribution of general creativity, divergent thinking in physics, scientific creativity in physics, intrinsic motivation, attitude towards physics, and self-efficacy to physics achievement.

Structural Model Analysis

The structural equation model involves the analysis of cause-and-effect relationships of all seven variables. Analysis of the structural model was performed until each relationship was statistically ($p < 0.05$) and practically ($\beta > 0.10$) significant. In the first time analysis, seven paths were eliminated because the value of β was negative or $\beta < 0.10$ and $p > 0.05$. The analysis results of the first structural model and the seven rejected paths are shown in Table 5.

After eliminating seven paths, a second-time analysis was performed, and the results showed two paths were eliminated because β was negative or $\beta < 0.10$ and p value> 0.05. The analysis results of the second structural model and the two rejected paths are shown in Table 6.

Table 5: Results of structural model analysis for the first time

				Estimate, β	S.E.	C.R.	p-value	Results
H2	PA	←	TCT-DP	.073	.038	2.379	.017	Rejected
H3	PA	←	DTP	.213	.910	3.494	***	Accepted
H4	PA	←	SCP	.639	.800	9.911	***	Accepted
H5	PA	←	IM	-.215	1.382	-3.005	.003	Rejected
H6	PA	←	ATP	.132	1.049	1.994	.048	Accepted
H7	PA	←	SE	.031	.647	.788	.430	Rejected
H8	DTP	←	TCT-DP	.254	.004	5.241	***	Accepted
H9	DTP	←	IM	-.193	.137	-1.828	.068	Rejected
H10	DTP	←	SE	.164	.071	2.582	.010	Accepted
H11	DTP	←	ATP	.296	.106	2.952	.003	Accepted
HI2	SCP	←	TCT-DP	.096	.004	2.504	.012	Rejected
H13	SCP	←	DTFP	.752	.059	15.195	***	Accepted
H14	SCP	←	IM	.183	.130	2.201	.028	Accepted
H15	SCP	←	SE	.092	.065	2.009	.045	Rejected
H16	SCP	←	ATP	-.187	.101	-2.361	.018	Rejected
H17	IM	←	SE	.426	.059	6.214	***	Accepted
H18	ATP	←	IM	.609	.105	7.090	***	Accepted
H19	ATP	←	SE	.230	.063	3.832	***	Accepted

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Table 6: Results of the second time structural model analysis

				Estimate, β	S.E.	C.R.	p-value	Results
H3	PA	←	DTP	.290	.676	5.176	***	Accepted
H4	PA	←	SCP	.599	.731	10.147	***	Accepted
H6	PA	←	ATP	-.014	.75	-.428	.669	Rejected
H8	DTP	←	TCT-DP	.268	.005	5.425	***	Accepted
H10	DTP	←	SE	.160	.086	2.566	.010	Accepted
H11	DTP	←	ATP	.143	.121	2.248	.025	Accepted
H13	SCP	←	DTP	.762	.051	14.591	***	Accepted
H14	SCP	←	IM	.079	.069	1.764	.078	Rejected
H17	IM	←	SE	.428	.059	6.270	***	Accepted
H18	ATP	←	IM	.597	.079	6.349	***	Accepted
H19	ATP	←	SE	.235	.045	3.799	***	Accepted

After eliminating seven paths on the first analysis and two paths on the second analysis, the structural model was analysed for a third time. The structural model results are shown in Figure 4. The analysis results show the nine paths tested in the final structural model are significant and practical. The final analysis showed that nine hypotheses were accepted (H3, H4, H8, H10, H11, H13, H17, H18, H19) while nine were rejected (H2, H5, H6, H7, H9, H12, H14, H15, H16). The hypotheses results and the coefficients for all significant paths in the final structural equation model are shown in Table 7.

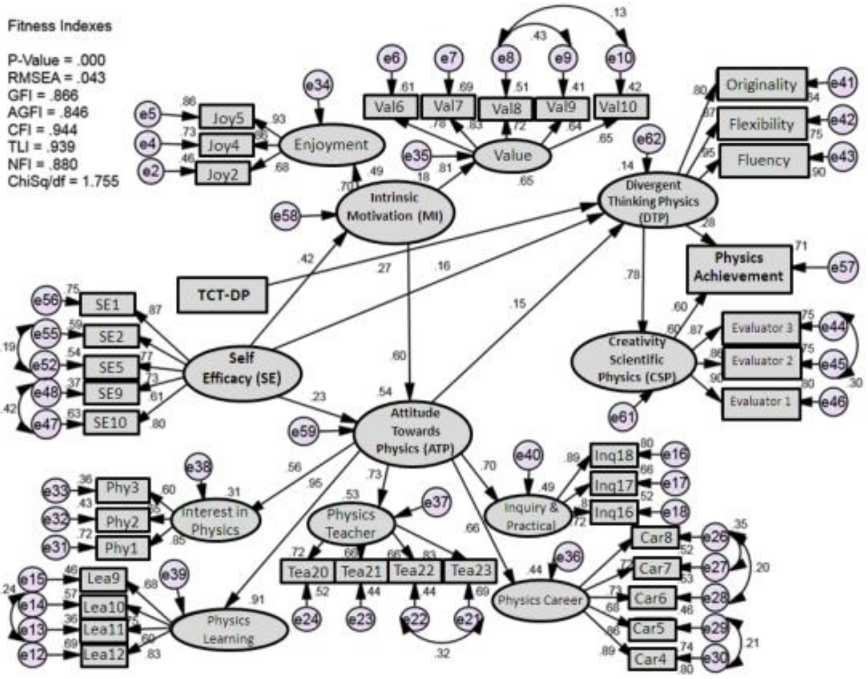

Fig 4. Final structural model

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Table 7: The coefficients of the paths in the final structural equation model

				Estimate, β	S.E.	C.R.	p-value	Results
H3	PA	←	DTP	.283	.677	5.052	***	Accepted
H4	PA	←	SCF	.602	.731	10.181	***	Accepted
H8	DTP	←	TCT-DP	.268	.005	5.433	***	Accepted
H10	DTP	←	SE	.161	.086	2.586	.010	Accepted
H11	DTP	←	ATP	.150	.121	2.220	.020	Accepted
H13	SCP	←	DTP	.777	.051	14.884	***	Accepted
H17	IM	←	SE	.424	.059	6.187	***	Accepted
H18	ATP	←	IM	.603	.080	6.376	***	Accepted
H19	ATP	←	SE	.235	.045	3.802	***	Accepted

Fitness indexes also meet the structural model analysis's fitness requirements, which shows that the structural equation model fits adequately to the research data (H1 accepted). The fit model with this data indicates that all the predictor factors selected based on the theory, model and previous studies are suitable and acceptable for practice in the classroom. The results of the fitness indexes of the final structural equation model are shown in Table 8.

Table 8. The results of the fitness indexes of the final structural equation model

Category	Type of Measure	Value	Acceptable Level of Fit
Absolute Fit	RMSEA	0.043	Yes
	GFI	0.866	No
Incremental Fit	CFI	0.944	Yes
	TLI	0.939	Yes
	NFI	0.880	No
	AGFI	0.847	No
Parsimonious Fit	Chisq/df	1.755	Yes

Contribution Strength

The most contributing cause and effect relationship can be identified through the standard regression weighting value (β). Table 9 shows a summary of the strength of each relationship based on the standard regression weights, β

Table 9. The strength of each relationship based on the standard regression weights, β

			Estimate, β	Strength
SCP	←	DTP	.777	High
ATP	←	IM	.603	High
PA	←	SCP	.602	High
IM	←	SE	.424	Moderate
PA	←	DTP	.283	Moderate
DTP	←	TCT-DP	.268	Moderate
ATP	←	SE	.235	Moderate
DTP	←	SE	.161	Moderate
DTP	←	ATP	.150	Moderate

The DTP→SCP contributes the strongest path in the model structural followed by SCP→PA, IM→STF and SE→IM. The most minor contributing relationships in this final model are the ATP→DTP, followed by the SE→DTP, SE→ATP, TCT-DP→DTP and DT→PA. The contribution strengths of DTP→SCP, SCP→PA and IM→ATP were in the high category while SE→IM, DTP→PA, TCT-DP→DTP, SE→ATP, SE→DTP and ATP→DTP were in the moderate category.

Discussion

The results showed that there were nine significant relationships while the other nine relationships were insignificant. Significant relationships indicate that it is important and should be given attention to students to be nurtured [38].

The contribution of scientific creativity towards physics achievement

Three cognitive variables are predictors of physics achievement namely TCT-DP, DTP and SCP. The results of the analysis showed that the general creativity or TCT-PD→PA relationship was statistically significant ($p < 0.05$) but not practically significant ($\beta < 0.1$). In contrast to the other two concepts of creativity, the analysis results showed that creativity domain physics, DTP→PA and SCP→PA relationship had a positive and statistically and practically significant effect. This study also provides an understanding that specific creativity in the domain of physics (DTP, SCP) plays an important role in influencing the achievement of physics compared to general creativity such as TCT-DP.

The strength of the relationship between DTP→SCP and SC→PA is also high. These findings provide meaningful information for believing that creativity domain physics make a valuable contribution to PA rather than general creativity. The role of scientific creativity in influencing academic achievement has been extensively studied [7]. Still, the findings obtained in this study are different from previous studies because the results of this study can distinguish the concept of creativity domain physics that directly influences PA from the concept of general creativity, which has no direct effect on the PA.

The differences in the findings are due to the context of DTP and SCP measurement were different from TCT-DP. DTP and SCP involve the same element as the physics achievement which is physics knowledge. Physics knowledge involved in the creativity domain physics such as DTP and SCP assists in problem-solving while answering physics questions. In this study, DTPT asked students to provide explanations using correct and accurate language by relating various concepts, principles and related theories of physics as a result of scientific observations and explanations. While SCPT is the ability to improve the quality of scientific products that encourages divergent and convergent thinking with the correct physics concept. It can be concluded that the DTP and SCP involves mastery of high physics knowledge and requires higher-order thinking skill. This mastery helps in solving PAT problems [12, 54]

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TCT-DP is not practical in improving physics achievement due to its small contribution strength (B <0.1). The findings of this study are in line with Urban (2004) stating that TCT-DP is not significantly related to academic achievement [55]. Nevertheless, in other studies it has been shown that the general creativity of TCT-DP influences academic achievement [10]. Various conflict findings of previous studies can be explained through the findings of the structural model analysis in this study. It was found that TCT-DP still influences physics achievement but not directly with the presence of mediator variables. The intended mediators that can be identified in the structural model are DTP and SCP. In other words, general creativity can still contribute to physics achievement but must involve both DTP and SCP.

The study of these direct and indirect relationships is important to ensure that the creativity cultivated in the classroom is appropriate to positively and effectively impact physics achievement. Based on the findings, it can be concluded that students' physics achievement can be improved by encouraging creative learning with divergent thinking and scientific creativity in physics. Not general creativity that has no implementation of scientific knowledge and skills in physics. In other words, physics achievement can be enhanced by cultivating student-centred activities that involve students generate many, varied, unique ideas and designing scientific products as an alternative to physics learning approaches.

The contribution of affective factors to physics achievement

Many previous researchers have cited affective factors as important factors in influencing cognitive development and academic achievement [27, 56]. However, the findings indicate that the three affective factors studied have no direct effect towards physics achievement. The relationships of EK→PF, STF→PF and MI→PF were eliminated from the structural model because the relationship was found not significant statistically and practically or were negatively effect to physics achievement. However, these affective factors still influence other variables such as ATP→DTP dan SE→DTP. This suggests that affective traits still exist but indirectly to physics achievement through DTP as a mediator.

The contradiction of these findings may be due to differences in study methodology [57]. SEM-AMOS analysis contains complex relationships between many variables. This may be why two theoretically positively related variables become negative when combined in one analysis in a structural model. According to Son (2009), the relationship between two variables being insignificant, low correlated or negatively related in a structural model can be due to several factors [16]. One of them is a more dominant relationship influencing endogenous variables or the existence of mediator variables [16].

Another reason may be that the variables and indicators studied do not use accurate and appropriate measurements. For example, intrinsic motivation indicators i.e. enjoyment and value may be less accurate for measuring their effect on PA. Reiss (2009) studied intrinsic motivation indicators that differ from enjoyment and value: fear of failure, curiosity, ambition, being organized, responsibility, and competition. Reiss stated that intrinsic motivation with such indicators can help students who are less excellent in academic achievement [58].

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According to Gungor, Eryılmaz and Fakioglu (2007), the appropriate motivation for physics achievement is achievement motivation, while Guido (2013) argues that the appropriate motivation to be studied together with physics achievement is extrinsic motivation [27, 59]. This provides a guide for selecting constructs and indicators is also very important in the analysis of structural equation models to obtain the significant practical effect.

Although the direct relationship of SE, IM and ATP with PA was respectively eliminated in the model, this does not mean that these three factors did not play an important role in contributing PA. Based on the structural model analysis, SE, IM and ATP still influence PA as stated in previous studies or models, however, in this study, the influence occurs indirectly on PA. These affective factors require cognitive factors such as DTP to contribute to PA. The indirect relationship of affective factors that interact dynamically with these cognitive factors is in line with most previous researchers who stated that affective factors need to be developed along with cognitive factors in influencing physics achievement [27].

Model Fit

The structural modeling analysis carried out in this study has validated the theories and models constructed by previous studies and also there is added value contributed. In Bloom's Taxonomy of learning (1956) only exhibits a general illustration of the relationship between affective factors and cognitive factors without specific information how the factors may affect the students' achievement [17]. This study also validates the contribution not only three different creativity approaches but also three important affective factors towards physics achievement.

This added some values to the existing theory and model as Model of Scientific Creativity by Son (2009) only involves scientific creativity, TCT-DP, intrinsic motivation and attitude in the field of science without self-efficacy while Amabile's (1983) theory involves only general creativity, scientific creativity and intrinsic motivation [16, 18]. The result of this structural model analysis can provide more comprehensive information to improve T&L physics practice among teacher and student in school.

CONCLUSION

Academic excellence, creativity, whether general or domain-specific, and positive affective development are important aspects to produce knowledgeable, creative, innovative, and high moral. Physics learning practices in the classroom need to be changed by allowing students to use their cognitive skills to the maximum. One way is to encourage students to think creatively and that creativity should be domain-specific creativity such as scientific creativity in physics. This follows the analysis of the structural equation model showing SCP and DTP give high contribution to PA. However, other predictive factors such as general creativity and affective factors also cannot be ignored. Although the relationship is indirect to PA, all of these factors contribute through a holistically practical and significant relationship in the structural model.

This model can benefit teachers, students and schools to increase the determination to cultivate creativity and help students in terms of emotions and attitudes. The implication is that the factors in this model can be used as guidelines on things that need to be emphasized in students related to domain-specific creativity and affective factors. Teacher can focus the T&L activities with creativity domain physics embedded because the skills found in this type of creativity can train future generations with creative and innovative skills and at the same time help in mastering physics concepts as well. Ongoing research is needed, and researchers hope that the findings of this study can benefit other researchers who are interested in conducting new research or continuing the existing structural model related to the physics achievement.

Further studies can be carried out using creativity instruments that measure other aspects or using more complex approaches such as creating creative products physically since the creativity measured in this study only uses pen and paper tests due to time constraints. In addition, SEM-AMOS analysis can analyze the effect of moderators, then further studies can examine the appropriate moderators to be studied and subsequently form a more comprehensive model to compare with the model in this study.

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