THE ROLE OF MATH AND SCIENCE EXPOSURE ON THE EFFECT OF 5E INSTRUCTIONAL MODEL IN PHYSICS CONCEPTIONS

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Abstract. *5E instructional model is commonly utilized in science teaching to promote conceptual learning. However, the benefit of 5E instructional model cannot be fully attained if the knowledge and skills essential to learning were not properly established from past. Similarly, the development of new concepts cannot be fully attained if the important processes inculcated in the 5E model were not considered in teaching. In this research, the effects of 5E model instruction and previous learning experiences on the conceptual learning of students in Newtonian mechanics were evaluated. Using 2 x 2 factorial research design, the conceptual understanding of 172 undergraduate students was evaluated before and after the experiment. These participants were distributed into four groups with different programs. The result revealed that both 5E instructional model and previous learning experiences contributed to the conceptual learning of students in mechanics. Those students who received 5E instructional model and whose exposure to science and math courses is high, gained the highest increase in the mean score after the experiment. This suggests that the effectiveness of 5E instructional model can be fully achieved if the knowledge and skills essential to learning and conceptual change were properly established from previous learning experiences and activities.*

Keywords: *5E model, conceptual change, conceptual learning, learning cycle, prior knowledge*

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Introduction

Instructional model, like the 5E instructional model, is a learning process model designed to promote students' decision making, problem solving ability and deeper understanding of concepts. The model encouraged students to use one's own knowledge and personal experiences to understand new concepts, design and perform inquiry processes, work collaboratively with peers, and apply the concepts learned to various perspectives (Rodriguez et al., 2019; Yaman & Karaşah, 2018). These processes, which can be traced from the early social constructivist perspective and which can be observed within the social context, are important in the development of new scientific concepts and are crucial to the progress of 21st century skills or information age skills (Sotáková et al., 2020; Vygotsky, 1978; Yaman & Karaşah, 2018). However, the pedagogical goal of 5E model will likely not succeed if the essential skills and knowledge needed for the processes to take place were not properly established from previous learning experiences (Ruppert et al., 2019). For example, in the learning process "engaging", students who lack fundamental skill and knowledge in doing science inquiry and hypothesis testing are more likely to acquire numerous trial and error during an experiment (van Riesen et al., 2018). Similarly, students who lack fundamental knowledge about force and motion are more likely to experience difficulties in relating variables about force and motion and unlikely to gain conceptual understanding in physics. These skills and knowledge, which developed prior to students' exposure to science and math courses from their previous years, are considered important for the success of 5E instructional model. Moreover, the development of schema is associated to early learning experiences (Graham et al., 2012). The association suggests that the ability of a person to interpret a certain phenomenon is related to the appropriateness of the schemas that have been developed from past learning experiences (Rowland et al., 2007). The implication suggests that exposures to science and math courses from the past learning experiences could serve as a good parameter to estimate the appropriateness of schemas needed to interpret problems in Newtonian mechanics. Thus, higher math and science exposure could lessen students' misconceptions in Newtonian mechanics which can result to correct interpretations of force and motion. Moreover, the development of schemas that students used in making sense of things around them happens during social interaction. Learning through social interactions creates

a plane to which the students internalize the information they received from their surroundings. The impact of students' learning experiences on the process of conceptual change reflects the importance of prior knowledge in the development of physics conceptions. However, despite of its significant role in learning, prior knowledge will less likely support conceptual change if instructional learning processes, like the processes stipulated in the 5E instructional model, will not be considered both by the learners and the teachers during the learning process (Arslan et al., 2015). For example, to activate curiosity and to make learning meaningful, students must realize the relevance of new concept they are learning, which happens during internalization processes or during sense making process. Despite of the importance of both 5E instructional model and learning experiences on the conceptual learning of the students in Newtonian mechanics, few studies have explicitly explored the interaction effect of 5E model and learning experiences in physics learning, and almost none have been conducted in the domain of Newtonian mechanics in the tertiary level. In response to the said challenge, this research has explicitly examined the effect of both instructional learning cycle model and previous exposures to science and math courses in the conceptual learning of students in Newtonian force using 2 x 2 factorial research design.

Conceptual Change

The 5E instructional model is established on a framework called constructivist learning theory. This framework explains that building of knowledge and meaning is a result of one's interaction with the environment. The fundamental framework that explains how learning happens in social interaction is the social constructivist perspective pioneered by Vygotsky (1978). According to this framework, social situations play an important role in learning. These situations include the exchange of information as a result of communication and collaboration between students. Moreover, the important role of prior knowledge in teaching and learning has been heavily studied in the field of science education research since the 1970s (Scott et al., 2007). One of the common research findings shows that learners across all levels hold concepts that are different to the concepts accepted in the scientific field. Wherein, designed teaching intervention is often used to improve students' conceptions. The common term usually coined with these odd conceptions is misconceptions (Rowlands et al., 2007). Misconception is said to be originated from daily life interactions with the environment, which in common situation are considered very useful in dealing with everyday life activities (Brown & Hammer, 2008). This is the reason why learners stand firm with the misconceptions they have and restrain instructional interventions designed to correct the misconceptions (Brown & Hammer, 2008; Rowlands et al., 2007; Scott et al., 2007). In the cognitive framework of learning, restructuring and reorganizing of knowledge are the processes that happen during conceptual change and are considered very important in learning and teaching. In some situation, learners need to undergo the process of conceptual change before they can gain a valid and justified understanding about their world. Restructuring of knowledge is very difficult for learners because it is during this process that learners need to connect existing concepts with the present concept they need to learn. Reviewing all research in the field of conceptual change, the majority of them have considered the cognitive aspect of conceptual change conceptualized by the group of Posner (1982). The group suggested that there are four conditions that need to attain before conceptual change happens. First, learners need to be dissatisfied with the current conceptions, second, learners should comprehend the new conceptions introduced to them, third, learners find the new conceptions reasonable and probable, and fourth, learners realize the meaning and use of the new conceptions. Based on the model proposed by Posner et al., (1982), cognitive conflict is considered the main factor that triggers cognitive disequilibration, which then results in the process of conceptual change. Learners realize the implausibility of their misconceptions and consider the plausibility of new conceptions. Aside from being subjected to plausibility, conceptual change is also characterized as progressive and continual rather than appearing instantly (Rowland et al., 2007; Scott et al., 2007). Constructivist theory highlighted the importance of prior knowledge in the process of conceptual change, arguing that the process of conceptual change is gradual which involves refinement of prior knowledge into a more structured and complex form, instead of replacing prior knowledge with a new accepted one (Schneider et al., 2012). Another theory that describes the formation of new conceptions is called the schema theory. Schema theory explains how learners organize their concepts to form a new concept. Schema refers to a group of concepts that learners used to make sense of their world. The schema used by students to make sense of their world can be associated to students' learning experiences, thus those students who have gained high exposures to a field they had studied before may develop a schema conducive to the same field they are studying at present (Rowlands et al., 2007). In this research, the effect of students' level of exposure to science and math on students' conceptual learning was evaluated.

5E Instructional Model

Reviewing some research papers in the field of science education that evaluated the effect of instructional models in learning, common result reveals that 5E instructional model is effective in improving students' conceptual learning (Arslan et al., 2015; Ceylan et al., 2009; Ören & Tezcan, 2009). The idea about learning cycle was first introduced by Atkin and Karpus (1962) using three stages namely exploring, discovering and creating. Relatively, in the model developed by Bybee and colleagues (2006), they suggested five stages of learning cycle activities, namely engaging, exploring, explaining, elaborating and evaluating. These processes were commonly known as 5E instructional model. In the engaging process, learners develop curiosity toward the concepts they need to learn and explore their prior knowledge to establish meaning about those concepts. During this process, learners are prompted to engage cognitively with the concepts they need to learn. When questions formed during the engagement process were answered, learners are said to be in the process of exploring. During this process, learners engage in inquiry learning activities to gather more evidence about the concepts they are studying. To deepen understanding of the concepts learned, students engage in discussion activities that will clarify questions they formed. During this stage, learners are said to be in the process of explaining. To make those concepts meaningful and useful, learners need to realize the uses and applications of those concepts to their life. During this time, learners are said to be in the process of elaboration. In the fifth cycle, evaluation stage, learners are encouraged to evaluate the processes they designed or evaluate the concepts they learned to further enhance the concepts they learned. To study the contribution of 5E instructional model in the conceptual learning of students in physics, its main effect was evaluated.

Exposure to Science and Math Courses

Prior knowledge is considered one important factor that influences students' learning development (Hailikari et al., 2008). The quality of understanding students can attain during the learning process depends on the degree of prior knowledge acquired by the students from their previous experiences. The quality and amount of knowledge acquired by students from previous learning experiences can be associated with the students' exposure to science and math courses taken before. Those students who credited more courses in the field of science and math could possibly acquire more prior knowledge in a field they have taken before, thus easily utilize the processes needed to undergo conceptual change. Previous exposures to science and math courses can contribute to the development of schema helpful in understanding the concepts of force and motion. Previous learning experiences in science and math courses contribute to the acquisition of concepts that learners can utilize in solving problems related to force and motion. It is during the process that learners retain information that is useful in their future learning activities. Previous learning experiences improve learners' problem-solving skills, critical thinking and creativity which are important in the process of conceptual change. Previous learning experiences promote the development of skill in knowledge restructuring. It is also the stage when skill in assimilation and accommodation is developed. Thus, one factor that needs to be considered in engaging learners to learning cycle is the level of learning experiences they gained from the past. Since the ability of the student to undergo conceptual change depends on the prior knowledge established from previous learning experiences, the effectiveness of 5E instructional model relies also on the knowledge and skills students established from previous learning experiences. Students' high school background affects students' performance in physics. In one of the research conducted before, the authors found that those students who credited physics courses in their senior-level high school scored higher compared to those students who were not able to credit any physics course in their senior-level high school (Harlow et al., 2014). The number of math courses completed in the past also contribute to the performance of students in FCI. In the research conducted by McCullough (2002) among 300 undergraduate students, the findings revealed that those students who completed the highest number of courses in math in their early studies performed better in the FCI compared those students who completed the lowest number of math courses in their past studies. Thus, to prove the role of previous learning experiences on the conceptual learning of the students, the effect of students' exposure to science and math courses to conceptual learning of the students was evaluated.

To explicitly examine the interaction effect of both teaching method and exposure to science and math courses on the conceptual progress of the students in Newtonian force, the following questions have been formulated.

1. How did the 5E instructional model contribute to the conceptual progress of the students in physics, particularly in the field of Newtonian mechanics?
2. How did the level of exposure in science and math courses contribute to the conceptual progress of the students in Newtonian mechanics?
3. What is the interaction effect of both the teaching method and science and math exposure in the conceptual progress of the students in Newtonian mechanics?

Research Methodology

General Background

2 x 2 factorial research design was utilized to evaluate the interaction effect of both teaching method and exposure to science and math (EMS) on students' conceptual understanding in Newtonian mechanics. Two factors (teaching method and ESM), consisting of two levels, were explored in this research. The factor 'teaching method' consists of two levels, the '5E instructional model method' and the 'conventional method'. The 5E instructional model method uses learning processes, such as 5Es, to guide students to develop deeper understanding of the concepts they need to learn. Conventional method, on the other hand, can be described as an expository teaching approach that usually starts through the review of previous lessons and ends through problem solving activities. The review is followed by an introduction of new concepts, presentation of solutions to problems, then problem solving activities for students. Aside from the teaching method, the ESM factor also consists of two levels, the 'high ESM' and the 'low ESM'. High ESM means higher exposure to science and math courses, while low ESM means lower exposure to science and math courses. The combination of two different levels has resulted to 2 x 2 factors or groups: 5E learning cycle method with 'high ESM' group; 5E instructional model method with 'low ESM' group; conventional method with 'high ESM' group; conventional method with 'low ESM' group. Figure 1 shows the group distribution.

Figure 1
Group Distribution Using 2 x 2 Factorial Design

		Teaching method	
		5E instructional model method	**Conventional method**
Exposure to science and math (ESM)	High ESM	Group 1	Group 3
	Low ESM	Group 2	Group 4

Participants

This research was carried through at a tertiary university in the Philippines. The participants are 178 2nd year undergraduate university students (95 males, 83 females; age distribution from 18 to 22) who are all enrolled in physics course that includes Newtonian mechanics in the course syllabus. The participants are distributed into four sections comprising of 43 students in engineering technology program, 42 students in teaching program, 47 students in computer science program, and 46 students in apparel and fashion design program. Considering the purpose of a research, it has been suggested that the minimum number of participants for each group must not be less than 30, thus a sample size higher than the suggested minimum sample size will least likely affect the reliability of the research results (Cohen et al., 2018, p. 203). The participants in the first and third groups credited the highest number of science and math courses prior to physics course, thus attained higher ESM. On the other hand, the participants in the second and fourth groups credited the least number of science and math courses prior to the current course in physics, thus attained least ESM. The participants were considered because their early exposure to science and math courses differs across the groups, which makes the groups comparable in terms of their early ESM. Other than that, most of the students who enter the school comes from the different regions of the country. Thus, they may be considered a good representation of the population. Furthermore, the treatment given to the participants was assured as the teacher handling the course is the same. This maintains the validity of the results of the research.

Research Instrument

To find out how the teaching methods and learning experiences contributed to the conceptual understanding of the students in Newtonian force, their physics conceptions on the said domain were pre-tested and post-tested using the Force Concept Inventory (FCI) instrument. The FCI is a 30-item concept inventory modelled to assess students' conceptions in Newtonian mechanics (Hestenes et al., 1992). Each item contains five options, one option is correct while four options are incorrect. The instrument contains items that probe students' understanding about force and motion in one or two dimensions. The distractors in the instrument represent students' misconceptions. Topics in Newtonian mechanics like conservation of energy and momentum were excluded in the instrument. To test its reliability, the instrument was piloted to 73 university students in engineering technology program. The result (α = .82) revealed a good statistical reliability. The instrument has been already utilized in other studies locally, and the results of reliability test indicate acceptable reliability. For example, in the research conducted by Morales (2017) on the conceptual progress of undergraduate students in Newtonian concepts, the computed coefficient alpha (α = .71) was statistically interpreted as good reliability.

Procedure

To figure out the interaction effect of the 5E instructional model and ESM on the conceptual gain of the students in Newtonian mechanics, three phases have been followed in this research. The first phase includes sampling, filling-out inform consent and pre-testing. The non-probabilistic convenience sampling has been considered to directly determine the role of learning experiences on the effect of teaching method on the conceptual understanding of students in mechanics. This sampling method has been considered so that the researcher could gather information that could provide answers to the research questions. Through proper consent, students were informed about the purpose of the research, the benefit that the research might contribute to them and to science education, and the confidentiality of the research. Students after this step were pre-tested using the FCI. Two teaching methods have been applied in the second phase of this research, the 5E instructional model method and the usual method used in teaching physics, which in this research was labelled as 'conventional method'. The first and the second class received 5E instructional model learning condition while the third and the fourth class received the usual method of teaching. Students' conceptual learning in Newtonian mechanics was re-evaluated using the concept inventory at the last phase of the research. All the scores gained by the students before and after the instructions were analyzed using proper statistical tools.

Data Analysis

The interaction effect of both the learning condition and ESM on the conceptual learning of the students in Newtonian mechanics was analyzed using Analysis of Covariance (ANCOVA). The validity of ANCOVA test was determined using the homogeneity regression slope test. Scattered plots (post-test scores vs pre-test scores) with respect to the independent variables were created to establish the validity of AVCOVA test. The intercorrelation between the dependent variables and the independent variables has been conducted to confirm the main effect of 5E instructional model and ESM on the post-test scores of the students in FCI. To determine which learning condition and level of ESM has significantly contributed to students' pre-test and post-test scores in the FCI, pairwise comparisons were computed. To evaluate the students' gain in score after the interventions, the pre-test mean-score and post-test mean score for each group were also compared using *t*-test.

Research Results

To determine the main effect of both teaching method and exposure to science and math (ESM) on the post-test scores of the students in Force Concept Inventory (FCI), Analysis of Covariance (ANCOVA) was computed. Homogeneity regression slope test was conducted to confirm the validity of the ANCOVA test. Results revealed a non-statistical difference between the teaching method and ESM ($F = 2.64$, $p > .01$), between the teaching method and pre-test scores ($F = 2.16$, $p > .01$), and between the pre-test scores and ESM ($F = 0.58$, $p > .01$). Results also showed that the regression slopes between the teaching method, ESM, and the pre-test scores are homogenous

to each other ($F = .19$, $p > .01$). The homogeneity or the non-significant difference between the slopes affirmed the validity of ANCOVA test. The scattered plots between pre-test and post-test scores in term of independent variables were shown in Figure 2.

Figure 2
Regression Slopes in Terms of Teaching Method and Exposures to Science and Math (ESM)
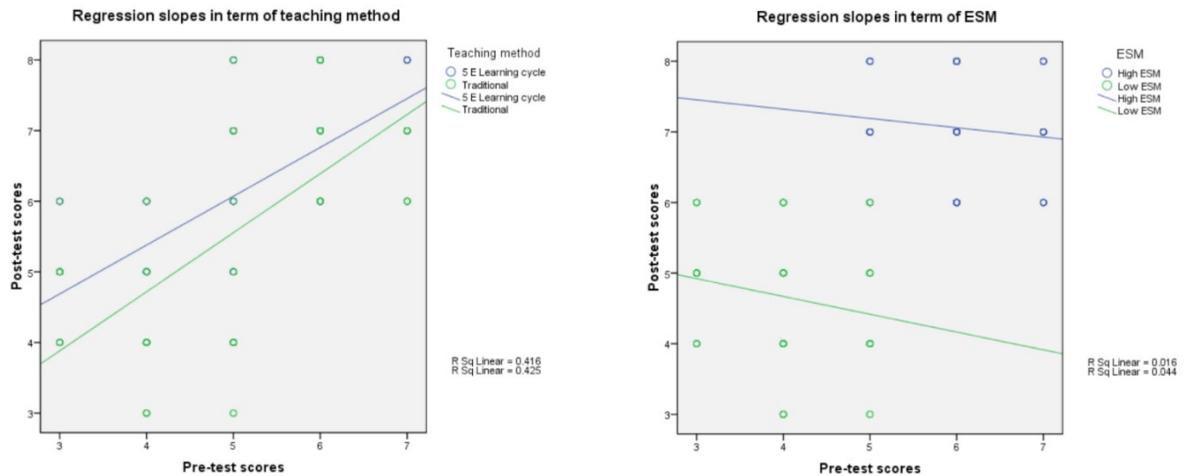
Note. High ESM = high exposures to science & math; Low ESM = low exposures to science & math.

The results of ANCOVA showed that pre-test scores (covariance) have significantly contributed to the FCI scores of the students in post-test ($F = 6.48$, $p < .05$, $\eta^2 = .04$). Moreover, results also showed that both teaching methods ($F = 21.42$, $p < .01$, $\eta^2 = .11$) and ESM ($F = 226.19$, $p < .01$, $\eta^2 = .57$) have significantly contributed to the post-test scores of the students in the FCI. The ANCOVA results also indicated that the 'combination effect' of the independent variables (teaching method and ESM) also contributed to the post-test scores of the students in FCI ($F = 7.52$, $p < .01$, $\eta^2 = .04$). The results confirmed the hypothesis that 5E instructional model and students' exposures to science and math courses have a main effect on the post-test scores of the students in FCI.

The intercorrelations among the independent and dependent variables were presented in Table 1, similarly, the significant difference between the variables was also presented in the said table. Using the conventional way in interpreting correlation coefficients articulated by Schober et al., (2018), the results revealed a negligible but non-significant correlation between ESM and teaching method ($r = .001$, $p > .05$), a negligible but non-significant correlation between pre-test scores and teaching method ($r = .005$, $p > .05$), a negatively weak but significant correlation between post-test and teaching method ($r = -.179$, $p < .05$), a negatively strong but significant correlation between pre-test and ESM ($r = -.819$, $p < .01$), a negatively strong but significant correlation between post-test scores and ESM ($r = -.841$, $p < .01$), and a positively moderate but significant correlation between post-test and pre-test scores ($r = -.635$, $p < .01$).

Table 1
Correlations among Dependent and Independent Variables

	Teaching method	ESM	Pre-test	Post-test
Teaching method	1			
ESM	.001	1		
Pre-test	.005	− .819**	1	
Post-test	− .179*	− .841**	.635**	1

** $p < .01$, two-tailed. * $p < .05$, two-tailed.

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To determine the main effect of teaching method and ESM on the pre-test scores of the students in FCI, pair-wise comparisons were presented in Table 2. A non-significant difference between the pre-test mean scores of 5E instructional model and traditional method has been observed. The hypothesis that teaching method has an effect on the pre-test scores of the students was rejected. Furthermore, result revealed a significant difference between pre-test mean score of high ESM and low ESM. This rejects the hypothesis that the students' level of exposures to science and mathematics has no effect on the pre-test mean scores of the students.

Table 2
Pre-test Pairwise Comparisons

Dependent Variable	Teaching method (N = 178)		ESM (N = 178)	
groups	Learning Cycle Group (n = 90)	Conventional Group (n = 88)	High ESM (n = 85)	Low ESM (n = 93)
M	5.02	5.03	6.00	4.05
SD	0.07	0.07	0.08	0.07
MD	0.01		1.95**	

Note. ESM = exposure to science and math; *n* = number of participants in a group; *N* = total number of participants; *M* = mean; *MD* = mean difference.
** $p < .01$, two-tailed. * $p < .05$, two-tailed.

Moreover, to determine the main effect of teaching method and ESM on the post-test scores of the students in FCI, pairwise comparisons were computed. The results revealed that both teaching method and ESM have a main effect on the post-test scores of the students in FCI. Whereas the difference between the post-test scores of 5E instructional model and traditional groups was statistically significant, same with the post-test mean scores of high ESM and low ESM groups. The hypothesis of non-significant effect of teaching method and ESM on the post-test mean scores of the students in FCI has been rejected.

Table 3
Post-test Pairwise Comparisons

Dependent Variable	Teaching Method (N = 178)		ESM (N = 178)	
groups	Learning Cycle group (n = 90)	Conventional group (n = 88)	High ESM (n = 85)	Low ESM (n = 93)
M	6.10	5.61	7.06	4.65
SD	0.08	0.08	0.08	0.08
MD	0.50**		2.41**	

Note. ESM = exposure to science and math; *n* = number of participants in a group; *N* = total number of participants; *M* = mean.
MD = mean difference.
** $p < .01$, two-tailed. * $p < .05$, two-tailed.

The change in the pre-test and post-test mean scores of the four groups of students was presented in Table 4. The group who has high ESM and was exposed to 5E instructional model gained the highest increase in the mean score after the instructions while the group who has low ESM and was exposed to the traditional teaching method gained the lowest increase in the mean score. The results also revealed a significant increase in the mean score of those groups who were exposed to 5E instructional model, but no significant increase for the group who received conventional method.

Table 4
Pre-test and Post-test Paired Sample Test

Teaching Method	ESM	n	Pre-test		Post-test		MD	t-value
			M	*SD*	*M*	*SD*		
5E instructional model	High ESM	43	5.98	0.71	7.16	0.72	1.19	7.73**
	Low ESM	47	4.06	0.70	5.04	0.69	0.98	6.25**
Conventional	High ESM	42	6.02	0.64	6.95	0.66	0.93	5.76**
	Low ESM	46	4.04	0.70	4.26	0.80	0.22	1.22
Total		178	4.98	1.19	5.80	1.43	0.82	9.60**

Note. ESM = Exposure to Science and Math; *n* = number of participants; *M* = mean; *SD* = standard deviation; *MD* = mean difference.
** $p < .01$, two-tailed. * $p < .05$, two-tailed.

Discussion

The interaction effect of both teaching methods (5E instructional model and traditional) and ESM on the conceptual learning of students in physics was evaluated in this research. To establish the validity of analysis of covariance (ANCOVA) test in finding the main effect of both independent variables, homogeneity regression slope test was conducted. Results revealed a non-significant difference on the regression slopes, indicating that AN-COVA test is valid for testing the main effect of 5E instructional model and ESM on the FCI scores of the students. The main effect of the teaching method on the FCI scores of the students was first studied. Results revealed that the teaching methods have significantly contributed to the FCI scores of the students after the interventions ($F = 21.42$, $p < .01$, $\eta^2 = .11$). The significant effect indicates that the teaching methods have significantly contributed to the conceptual understanding of the students in Newtonian mechanics. This main result was further analyzed using pairwise comparison for both pre-test and post-test. Results revealed that the post-test mean score of the 5E instructional model group is significantly higher than the post-test mean score of the conventional group (Table 3). The significant result suggests that the 5E instructional model is more effective compared to the conventional method in improving students' conceptual understanding in physics. The effectiveness of the 5E instructional model has been confirmed by the correlation coefficient between the teaching method and the post-test results ($r = -.179$, $p < .05$) in Table 1, indicating that the 5E instructional model group significantly exceeded the conventional group in the post-test results. Furthermore, pairwise comparison also revealed that both teaching methods have no main effect on pre-test scores of the students (Table 2), indicating that the significant difference in the mean scores of the two groups was only observed after students were exposed to the interventions. The effectiveness of 5E instructional model in the conceptual progress of students in physics has been also confirmed in the pre-test-post-test mean score comparison in Table 4. Wherein, those students who received 5E instructional model method obtained the highest increase in post-test mean score as compared to those who received the conventional way of teaching. The effectiveness of 5E learning model in students' conceptual learning was also observed in other studies. In the research conducted previously, the authors proved that 5E instructional model is very effective in promoting students' conceptual learning in cell division and reproduction (Arslan et al., 2015). Wherein those students who received 5E instructional model significantly gained in their post-test score as compared to those who received conventional teaching. The effect of '5E model' on the conceptual learning of students in physics suggests that this teaching model helped students activate conceptual learning in physics. During the process, learners restructure new information in order to acquire an understanding of the present situations. This occurs when learners engage in 'inquiry processes activities' (van Riesen et al., 2018). This instructional model, which derived from the constructivist learning perspective, promotes knowledge construction, especially when learners internalize the information acquired during learning. The effect of students' exposure to science and math on their conceptual learning was also evaluated. Results revealed that students' EMS significantly contributed to the FCI scores of the students after the interventions ($F = 226.19$, $p < .01$, $\eta^2 = .57$). The result indicates that earlier exposure to science and math courses contributed to the conceptual progress of students in Newtonian mechan-

ics. The result was further analyzed using pairwise comparisons. Results revealed that the pre-test mean score of the high ESM group significantly exceeded the pre-test mean score of the low ESM group (Table 2). Similarly, result also revealed that the post-test mean score of the high ESM group significantly exceeded the post-test mean score of the low ESM group (Table 3). These outcomes indicate that exposure to science and math has a significant contribution to the conceptual understanding of students in physics. The main effect of ESM on both pre-test and post-test scores of the students has been confirmed by the correlation coefficients between ESM and pre-test scores ($r = -.819$, $p < .01$) and between ESM and post-test scores ($r = -.841$, $p < .01$). The correlations indicate that the high ESM group significantly exceeded the low ESM group both in the pre-test and post-test mean scores. Furthermore, the contribution effect of ESM has been also confirmed in the pre-test-post-test mean score comparison in Table 4, those groups who completed the highest number of courses in science and math obtained the highest increase in the post-test mean score as compared to those groups who credited the least number of courses in science and math. In a research that evaluated the relationship between students' high school background and FCI performance, the authors proved that those students who took physics in the senior-level high school scored significantly higher than those students who did not take senior-level high school physics course (Harlow et al., 2014).This suggests that the students' earlier exposure to physics courses is one of the factors that contributed to their FCI scores. In the research conducted by McCullough (2002) among 300 undergraduate non-physics students about the effect of math background on the performance of students in FCI results revealed that those students who completed the highest number of math courses in the senior high school and early undergraduate level obtained the highest mean score in the FCI test as compared to those students who credited the lowest number of courses in math. Students' early exposure to science and math courses contributed to the conceptual progress of the students in physics. Wherein those students who have high exposure in science and math courses perform better than those students who have low exposure in science and math courses. Learning experiences from the past is considered the main source of schemas that students used when interpreting unfamiliar situations (Graham et al., 2012). Schema, which consists clusters of related concepts, is useful when analyzing problems in Newtonian mechanics. Aside from that, previous exposure to science and math courses promotes learners' problem-solving skill and critical thinking skill, which are important during the process of conceptual change. Learning processes such as restructuring of knowledge are part of early learning experiences (Scot et al., 2007).To determine how the interaction between independent variables contributed to the conceptual understanding of the students in physics, the interaction effect of both teaching methods and ESM on conceptual learning of the students was evaluated. The result revealed that both teaching method and ESM have a main effect on the FCI test results ($F = 7.52$, $p < .01$, $\eta^2 = .04$). The main effect indicates that both teaching method and ESM have contributed to the conceptual understanding of students in Newtonian mechanics. The combinational effect of the said factors in the FCI test scores can be further analyzed on the paired sample test in Table 4. Based from the 2 x 2 experimental design, the result revealed that the group who has high ESM and at the same time received 5E instructional model gained the highest increase in the FCI test, while the group who has low ESM and at the same time received conventional teaching gained the lowest increase in the FCI test. These results imply that higher exposure to science and math courses contribute to students' conceptual learning and become more effective if the 5E instructional model is considered in teaching. Prior knowledge, which developed from previous learning experiences, could serve as schema which students utilize when interpreting situations unfamiliar to them. However, the activation of a schema will become gradually if learners will not be engaged in learning activities that involve observations, predictions, testing, application, and evaluation. These processes, embedded in the 5E instructional model, promote conceptual learning.

Conclusions and Implications

Relating students' prior knowledge in the concepts they need to learn, engaging learners in inquiry-based learning activities and helping students to apply and validate the concepts they learned are part of students' learning development. These activities, inculcated in the 5E instructional model, are very important for the process of conceptual change. However, many teaching practices are still relying on traditional way of teaching, that is more teacher-centered rather than student-centered teaching. Important learning processes such as engaging, exploring, explaining, elaborating and evaluating are often not emphasized during the learning process. However, even though '5E learning model' is considered, learners can still experience impediment in understanding the concepts they need to learn if the knowledge and skills relevant to their present situation were not properly developed from

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previous learning experiences. Same also when students' exposure to science and math courses from previous studies is very low, the essential skills and knowledge needed by students to undergo the process of conceptual change become less available when they encounter questions unfamiliar to them. Whereas, the effectiveness of 5E instructional model cannot be fully achieved if the important skills and knowledge needed to process conceptual change were not properly developed from previous learning experiences. In this research the interaction effect of both 5E leaning and previous learning experiences to students' conceptual learning was studied. Results revealed that both 5E learning model and previous exposures to science and math courses contributed to the conceptual learning of the students. Those students who received 5E instructional model during the instructions significantly performed better on the FCI test than those who were assigned to conventional teaching method. The effectiveness of 5E instructional model suggests that the model promotes conceptual understanding, promotes students' curiosity, encourages learners to engage in interactive discussion, and it encourages learners to apply the skills and knowledge they learned. On the other hand, those students who credited the highest number of courses in science and math in their previous studies significantly performed better compared to those who credited the smallest number of courses science and math. The significant result suggests that previous learning experiences serve as a source of knowledge which students restructure to develop new concepts. Furthermore, the interaction effect of both teaching methods and learning experiences also contributed to the conceptual learning of the students. Whereas, those students who received 5E instructional model and credited the highest number of courses in science and math gained the highest increase in the mean score after the experiments compared to the other groups. The outcome suggests that prior knowledge developed from previous learning experiences plays an important role in the development of new knowledge and should be considered when using 5E learning in teaching. Students' unproductive learning experiences from the past studies could be one factor why the effectiveness of 5E instructional model in learning is not fully attained. Similarly, when knowledge construction and skill development were not given emphasis during instructions, the knowledge learned from the past often fails to transform into a new knowledge. The effective conceptual learning can be fully attained if two conditions were satisfied: well established prior knowledge and high emphasis on knowledge construction during teaching.

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