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Learning Activity Matters: Tips for Student Engagement

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This study aims to determine the learning activity methods (technology-based, game-based, art-based, discussion, experimental and calculation-based) that the students attended the most and the least, and reveal the predictive status of the activity characteristics (attractiveness, instructiveness and usefulness) and the target audience in the engagement of the students. A researcher-developed self-report questionnaire was implemented to 4416 students from preschool to university level in a science festival. Descriptive statistics and multinomial logistic regression analysis were used to analyze the data. The findings indicated that the highest engagement rate was for games-based activities, while the lowest was for technology-based activities. Additionally, the attractiveness, instructiveness of the activity, and the target audience predicted students' engagement in the learning activity. Consequently, increasing the attractiveness of the activity affects the probability of engaging in technology-based, game-based, and art-based activities over calculation-based. Similarly, increasing the instructiveness of the activity affects the probability of engaging in calculation-based activities over technology-based and art-based activities. The findings also showed that elementary and middle school students had similar preferences for engaging in learning activities, while high school students did not. However, the usefulness of the activity was not a predictor variable. The potential reasons for the findings were discussed and some recommendations were proposed.

Introduction

Various frameworks (e.g., European Key Competencies for Lifelong Learning, The P21 Framework) are proposed to raise the human profile needed in the future in social and economic contexts. It is possible only with effective learning environments that can be formal, nonformal, or informal. The learning environment is "the intellectual, social, emotional, and physical environments in which students learn" (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010, p.170). Therefore, learning environments have an impact on student learning outcomes (Cayubit, 2022; Hanrahan, 1998; Malik & Rizvi, 2018; Opdenakker & Minnaert, 2011; Usman & Madudili, 2019) and promote the skills and competencies proposed by these frameworks (Agaoglu & Demir, 2020; Qian & Clark, 2016).

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The fundamental task of an instructor is to find effective ways to engage students in the learning environment. One of these ways is through learning activities. The learning activity can be defined as a bridge between the learners and the learning outcome. Learning activities include examples from games to computer simulations. Furthermore, learning activities allow students to develop mental skills and analysis abilities (da Silva Clarindo, Miller & Kohle, 2020), promote student engagement (Gunes, Arikan & Cetin, 2020), and increase students' achievements in addition to helping teachers design teaching/learning processes (Nasrullah, Khan, Matiullah, Kamal & Khan, 2017).

Most researchers reported the effectiveness of different learning activities. For example, Zhu (2012) stated that guessing games, discussion activities, and role-playing could improve student communication skills. Similarly, Anwer (2019) found that teaching with hands-on activities significantly increased students' interests and academic achievements. Furthermore, different studies revealed the effect of game-based activities on the development of personal, social, language, and fine motor skills of individuals (Arcagok, 2021; Taner Derman, Sahin Zeteroglu & Ergisi Birgul, 2020). Other studies reporting the effect of art-based activities on conceptual understanding of chemistry (Danipog & Ferido, 2011), eco-awareness, and environmental knowledge (Staples, Larson, Worsley, Green, & Carroll, 2019), in addition to studies regarding the positive effects of various activities such as laboratory, coding, and discussion on students' science understanding, self-efficacy perception, attitudes. (Gericke, Högström & Wallin, 2022; Green, 2012; Kasalak & Altun, 2020; Shana & Abulibdeh, 2020; Towsend, 2012; Yildiz & Seferoglu, 2021).

The preferred teaching method is an essential factor affecting students' learning (Fernandez-Garcia, Maulana, Inda-Caro, Helms-Lorenz & Garcia-Perez, 2019; Inda-Caro, Maulana, Fernandez-Garcia, Pena-Calvo, Rodriguez-Menendez & Helms-Lorenz, 2019). However, their influences on students' involvement/engagement are also important. Therefore, this study primarily examines the learning activity methods that students engaged primarily in and the factors that affect their engagement in these activities. There are some reasons for this research. One reason is the study by Agaoglu and Demir (2020), which states that designing appropriate activities can promote the skills of the 21st century. The other reason is the results of studies reporting the relationship between student engagement and learning activities (Oncu & Bichelmeyer, 2021; Swarat, Ortony, & Revelle, 2012; Thomas, Pavlechko & Cassady, 2019).

Karns (2005) expressed that internships, class discussions, and case analyses with the most preferred reasons for enjoyable, challenging, and real-world practices were the most engaging learning activities for marketing students. Similarly, Simonds and Brock (2014) reported that older students mainly watched the lecturer's videos, while the younger students engaged mainly in interactive learning activities in an online course. In English reading and writing lessons, visualised materials such as PowerPoint presentations had the highest engagement, while pair or group work had the lowest (Nam & Seong, 2020). Additionally, English Language Teaching students were interested in teacher-centred activities such as listening, grammar, and pronunciation and focused more on the funny aspects of the activities rather than instructional (Sanchez, 2017).

Rare studies of student engagement and learning activity indicate the need for further studies. In this context, this study aims to determine the learning activity methods that students mainly engaged in and reveal the predictive status of activity characteristics (attractiveness,

instructiveness, and usefulness) and the target audience in the engagement of the students. The originality of the study is based on two aspects. Firstly, this study focusses on various activity methods, including multiple learning topics. Secondly, it presents findings regarding the participation of a wide range of grades in learning activity methods.
The results of this study directly contribute to instructional planning. Determining the predictive status of the activity characteristics in student engagement will allow teachers to improve their instruction. Teachers will also be informed about the factors considered when designing in- or out-of-classroom activities. Similarly, determining the predictive status of the target audience will allow teachers to design effective learning environments for students with different grades. Therefore, it potentially increases students' learning outcomes, such as motivation and academic achievement. The following research questions were addressed in this study:

- Which learning activity method has the highest rate of students' engagement?
- Do the characteristics of the activity and the target audience predict the students' engagement in learning activities?

Method

This study used a quantitative survey method. The reason for choosing this method is to determine students' engagement in learning activity methods in a science festival. The study used the cross-sectional survey method since the data were collected at just one point (Fraenkel & Wallen, 2009).

Participants

The study originated from a city-wide science festival arranged between 29 September and 1 October 2022 in Turkey. During the festival, students with different grades experienced activities based on their desire and learning needs. At the end of each activity, they were asked to answer questions related to the activity. Therefore, the study participants were selected based on random sampling, as Fraenkel and Wallen (2009) stated.
Data on demographic information of students are presented in Figure 1.

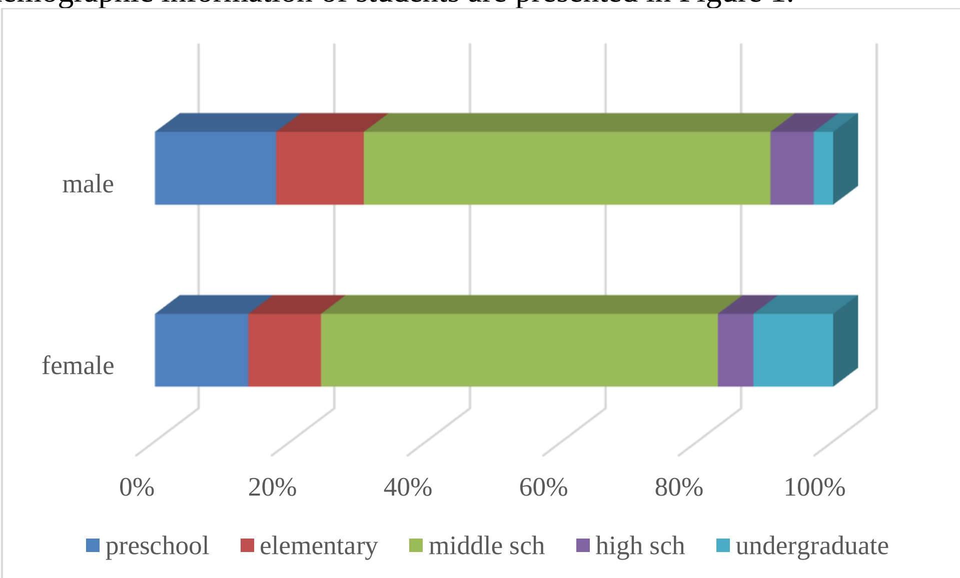

Figure 1. Distribution of students according to gender and grades

The total number of participants was 4416, and 55% were female (2428 out of 4416). Two thousand six hundred thirteen students were from middle schools (59.17%), 689 students were from preschools (15.60%), 517 students were from elementary schools (11.71%), 343 students were undergraduates (7.77%), and 254 students were from high schools (5.75%) in decreasing order, respectively.

Data Collection

The Attendees' Comments Form, a self-report survey, was used as a data collection tool. The author developed it to obtain information about the selection of learning activity methods by students and the reasons for their selection. The form includes four main questions: gender, group, activity name, and comments. The comment part has a Likert-type scoring method and asks students to score the attractiveness, instructiveness, adequacy of the activity coordinator, the scheduled time, and usefulness between '5 for Excellent' and '1 for Poor'. However, scores on the adequacy of the activity coordinator and the scheduled time were not included in the analysis due to the research problem. The validity of this self-report survey was provided through expert views. In this regard, the survey questions were reviewed by three academics: two from the fields of measurement studies and one from the field of science education. All agreed on the suitability of the survey.

Data were collected by implementing the data collection tool directly to participants after they experienced the activity. Direct implementation was preferred because of the high amount of data. All questions were organised as multiple choice questions because they facilitated the answering process and allowed the researcher to obtain standardised data.

Data Analysis

Descriptive statistics were used to analyse the first research question, while multinomial logistic regression (MLR) was used for the second research problem. MLR predicts membership between variables with more than two categories (Field, 2009).

Multicollinearity was checked first to determine whether the data were appropriate for MLR analysis. For this, the correlation coefficients between the predictive variables were calculated and there were no multicollinearity found. Furthermore, the statistical tests were interpreted based on a .0125 value, calculated by dividing the standard p-value by the total number of predictor variables to eliminate the Type I error, as Tabachnick and Fidell (2007) proposed. Finally, the calculation-based activity method (CBA) was selected as a reference category.

Ethics Committee Approval

All data collection tools and informed consent forms were reviewed and approved by the Pamukkale University Social and Human Sciences Research and Publication Ethics Committee (25.02.2022/ Document Number: 175306)

Results

The analyses on the first research question showed that 36.53% of the students engaged in game-based activities (GBA), while only 7.61% engaged in technology-based activities (TBA).

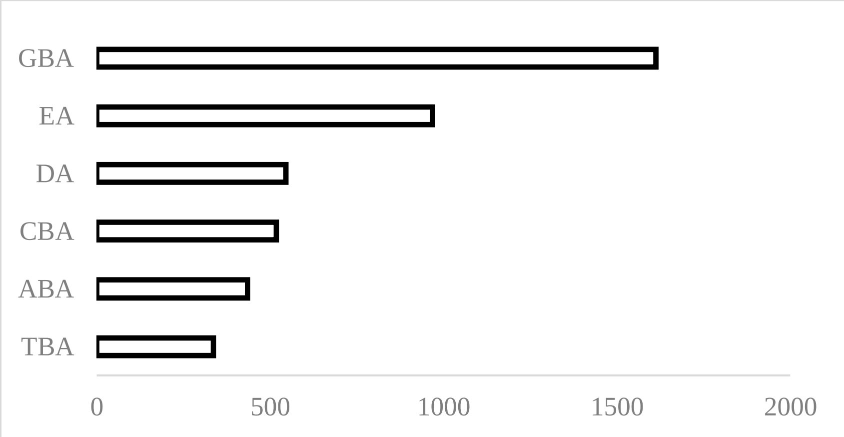

Figure 2. Engagement of students in learning activity methods

Note. The x-axis shows the number of students who are engaged in a specific learning activity method.

GBA: game-based activities; EA: experimental activities; DA: discussion activities; CBA: calculation-based activities; ABA: art-based activities; TBA: technology-based activities

Regarding the second research problem, the outcome variable was the learning activity method, which has six categories (technology-based activities [TBA], experimental activities [EA], calculation-based activities [CBA], art-based activities [ABA], discussion activities [DA], and game-based activities [GBA]). In contrast, the predictor variables were attractiveness, instructiveness, usefulness of the activity, and target audience. Table 1 shows the variables in the new model.

Table 1 Summary of case processing

		N	Marginal percentage
Activity method	TBA	336	7.6%
	EA	968	21.9%
	GBA	1613	36.5%
	DA	546	12.4%
	ABA	435	9.9%
	CBA	518	11.7%
Target audience	preschool	689	15.6%
	elementary	517	11.7%
	middle school	2613	59.2%
	high school	254	5.8%
	undergraduate	343	7.8%
Valid		4416	100.0%
Missing		0	
Total		4416	
Subpopulation		208[a]	

a.The dependent variable has only one value observed in 96 (46.2%) subpopulations.

Table 2 indicates whether the new model with predictive variables was better than the original model.

Table 2 Model Fitting Information

Model	Model-fitting criteria			Likelihood ratio tests		
	AIC	BIC	-2 Log-likelihood	X^2	df	P
Intercept Only	3849.49	3881.46	3839.49	2277.82	35	.000*
Final	1641.67	1897.39	1561.67			

*p<.0125

Table 2 shows the data on the suitability of the new model. A decrease in AIC and BIC values implies that the new model is better (Field, 2009). Furthermore, the chi-square statistics, which test the decrease in unexplained variance between the original and new models, are significant (p<.0125). All these values indicate that the new model is more appropriate than the original one.

Additionally, Table 3 was examined to determine whether the data suited the model.

Table 3 The Goodness of Fit Indices

	X^2	df	p
Pearson	1204.31	1000	.000*
Deviance	883.94	1000	.996

*p<.0125

Pearson and deviance statistics with no significant values show that the new model is good (Karagoz, 2017). However, as shown in Table 3, there is a problem with Pearson's statistics. It may stem from the data overdispersion and can be checked by dividing chi-square values by the degree of freedom (Field, 2009). According to this formula, the probability of overdispersion for Pearson's statistics is 1.17, while 0.87 for deviance statistics. The fact that both values are close to the ideal value of 1 shows that there is no overdispersion problem.

The pseudo-R2 values, used to determine the predictive strength of the model, are 0.40 for Cox and Snell and 0.42 for Nagelkerke. Although these values show which percentage of dependent variables is explained by independent variables, according to Karagoz (2017), there is no consensus on its interpretation.

Previous findings indicated that the new model with predictive variables is better than the original model; however, the likelihood ratio test was examined to determine which predictive variable(s) is/are significant for the model. Table 4 shows the results of the likelihood ratio test.

Table 4 Likelihood ratio test results

Effect	Model-fitting criteria			Likelihood ratio tests		
	AIC of the reduced model	BIC of the reduced model	-2 log-likelihood of the reduced model	X^2	df	p
Intercept	1641.67	1897.39	1561.67[a]	.000	0	.
attractiveness	1705.98	1929.73	1635.98	74.31	5	.000*
instructiveness	1680.47	1904.22	1610.47	48.80	5	.000*
usefulness	1638.68	1862.43	1568.68	7.01	5	.220
target audience	3670.05	3797.91	3630.05	2068.38	20	.000*

Notes. The chi-square statistic is the difference in -2 log-likelihoods between the final and reduced models. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model, because omitting the effect does not increase the degrees of freedom. *p<.0125

Table 4 shows that the attractiveness of the activity ($X^2(5) = 74.31$, $p<.0125$), instructiveness ($X^2(5) = 48.80$, $p<.0125$), and the target audience ($X^2(20) = 2068.38$, $p<.0125$) have significant effects on students' engagement in the learning activity method, while the usefulness of the activity does not ($X^2(5) = 7.01$, $p>.0125$).

Table 5 shows the regression coefficients and their significance for the predictive variables in the new model.

Table 5 Parameter Estimates

	B (SE)	Odds ratio	95% CI for the odds ratio Lower bound	Upper bound
TBA vs. CBA				
Intercept	-.63 (.61)			
attractiveness	.56 (.14)*	1.75	1.33	2.29
instructiveness	-.72 (.14)*	.49	.37	.64
usefulness	-.19 (.13)	.83	.65	1.07
preschool	18.67 (2067.30)	128370896.79	.000	.[b]
elementary	20.24 (.43)*	617395108.41	268469805.97	1419812252.29
middle school	1.88 (.23)*	6.55	4.14	10.34
high school	4.24 (.38)*	69.63	33.29	145.63
undergraduate	0[c]	.	.	.
EA vs. CBA				
Intercept	-1.00 (.56)			
attractiveness	.225 (.12)	1.25	.99	1.59
instructiveness	-.30 (.13)	.75	.58	.96
usefulness	-.12 (.12)	.89	.71	1.11
preschool	23.01 (2067.30)	9879732726.00	.000	.[b]
elementary	21.72 (.33)*	2704550511.15	1419326137.32	5153567791.80
middle school	2.37 (.20)*	10.70	7.28	15.73
high school	3.90 (.36)*	49.38	24.47	99.64
undergraduate	0[c]	.	.	.
GBA vs. CBA				
Intercept	-3.20 (.64)			
attractiveness	.31 (.11)*	1.37	1.09	1.70
instructiveness	-.25 (.12)	.78	.61	.99
usefulness	-.14 (.11)	.87	.70	1.08
preschool	24.69 (2067.30)	52739024630.58	.000	.[b]
elementary	24.69 (.46)*	52559552575.70	21196661843.12	130327434923.66
middle school	4.80 (.39)*	121.81	56.68	261.76
high school	4.03 (.53)*	56.41	19.83	160.52
undergraduate	0[c]	.	.	.
DA vs. CBA				
Intercept	-1.60 (.62)			
attractiveness	-.09 (.12)	.91	.73	1.14
instructiveness	-.09 (.13)	.92	71	1.19
usefulness	-.18 (.12)	.84	.67	1.05
preschool	3.42 (2882,51)	30.49	.000	.[b]
elementary	22.29 (.46)*	4793005997.11	1965839364.70	11686054771.74
middle school	3.82 (.35)*	45.53	22.98	90.22
high school	3.94 (.49)*	51.43	19.72	134.14
undergraduate	0[c]	.	.	.
ABA vs. CBA				
Intercept	-4.50 (.76)			
attractiveness	.87 (.16)*	2.38	1.74	3.24
instructiveness	-.51 (.14)*	.60	.46	.79
usefulness	.05 (.13)	1.05	.81	1.37
preschool	18.83 (2067.30)	149773096.41	.000	.[b]
elementary	21.82 (.46)	2996600651.46	2996600651.46	2996600651.46

middle school	2.82 (.25)*	16.82	10.34	27.37
high school	2.66 (.47)*	14.22	5.63	35.95
undergraduate	0[c]	.	.	.

Notes. a. The reference category is calculation-based activities

b. The floating point overflow occurred while computing this statistic. Its value is, therefore, set to system missing.

c. This parameter is set to zero because it is redundant.

*p<.0125

Technology-based activities vs. Calculation-based activities

According to Table 5, the attractiveness of the activity is an important factor for students' engagement in TBA instead of CBA (B= .56, Wald $x^2(1)$= 16.24, p<.0125). The odd ratio shows that increasing the attractiveness of the activity affects the probability of engaging in TBA over CBA 1.75 times more. The activity's instructiveness is an essential factor for engaging in TBA instead of CBA (B= -.72, Wald $x^2(1)$= 27.44, p<.0125). The odd ratio shows that increasing the instructiveness of the activity affects the probability of engaging in TBA over CBA 0.49 times less. In other words, instructiveness affects the probability of engaging in CBA over TBA 2.04 (1/0.49) times more. Further, being an elementary (B= 20.24, Wald $x^2(1)$= 2269.40, p<.0125), middle (B= 1.88, Wald $x^2(1)$= 64.87, p<.0125), or high school student (B= 4.24, Wald $x^2(1)$= 127.03, p<.0125) is significant factor in engaging in TBA instead of CBA. Accordingly, elementary school students are 617395108.41 times more likely to engage in TBA than CBA compared with undergraduates. Similarly, middle school students are 6.55 times and high school students are 69.93 times more likely to engage in TBA than CBA compared with undergraduates.

Experimental Activities vs. Calculation-Based Activities

As seen in Table 5, the target audience is the only significant factor in engaging in EA instead of CBA. Accordingly, elementary school students are 2704550511.15 times more likely to engage in EA than CBA than undergraduates. Similarly, middle school students are 10.70 times more likely to engage in EA than CBA, while high school students are 49.38 times more.

Game-based activities vs. Calculation-based activities

The attractiveness of the activity is a significant factor for engaging in GBA instead of CBA (B= .31, Wald $x^2(1)$= 7.60, p<.0125). The odd ratio shows that increasing the attractiveness of the activity affects the probability of engaging in TBA over CBA 1.37 times more. Furthermore, being an elementary (B= 24.69, Wald $x^2(1)$= .00, p<.0125), middle (B= 4.80, Wald x2(1)= 151.40, p<.0125), and high school student (B= 4.03, Wald $x^2(1)$= 57.13, p<.0125) are significant factors for engaging in GBA instead of CBA. Accordingly, elementary school students are 52559552575.70 times more likely to engage in GBA than CBA compared with undergraduates. Similarly, middle school students are 121.81 times, and high school students are 56.41 times more likely to engage in GBA than CBA compared with undergraduates.

Discussion activities vs. Calculation-based activities

Only the target audience is influential in selecting DA instead of CBA, as in EA. For example, according to Table 5, elementary school students are 4793005997.11 times more likely to engage in DA than CBA than undergraduates. Similarly, middle school students are

45.53 times more likely to engage in DA than CBA, while high school students are 51.43 times more.

Art-based activities vs. Calculation-based activities

Table 5 shows that the attractiveness of the activity is a significant factor in engaging in ABA instead of CBA (B= .87, Wald $x^2(1)$= 29.63, p<.0125). The odd ratio shows that increasing the attractiveness of the activity affects the probability of engaging in ABA over CBA 2.38 times more. The activity's instructiveness is the other significant factor for engaging in ABA instead of CBA (B= -.51, Wald $x^2(1)$= 13.27, p<.0125). The odd ratio shows that increasing the instructiveness of the activity affects the probability of engaging ABA over CBA 0.60 times less. In other words, instructiveness affects the probability of engaging in CBA more than ABA 1.67 (1/0.60) times more. Furthermore, being a middle school student (B= 2.82, Wald $x^2(1)$= 129.15, p<.0125) or high school student (B= 2.66, Wald $x^2(1)$= 21.47, p<.0125) is the influential factor in engaging in ABA instead of CBA. Accordingly, middle school students are 16.82 times higher and high school students are 14.22 times more likely to engage in ABA than CBA than undergraduates.

The classification table was also examined to test the usefulness of the model. Table 6 shows the percentages of accurately predicted cases.

Table 6. Classification table for the usefulness of the model

	Predicted						
Observed	TBA	EA	GBA	DA	ABA	CBA	Percent Correct
TBA	44	57	203	7	0	25	13.1%
EA	36	61	820	15	0	36	6.3%
GBA	7	30	1532	37	0	7	95.0%
DA	2	25	476	33	1	9	6.0%
ABA	6	8	393	7	1	20	0.2%
CBA	4	9	247	12	0	246	47.5%
Overall percentage	2.2%	4.3%	83.1%	2.5%	0.0%	7.8%	43.4%

Table 6 shows that the final model accurately predicted 43.4% of the cases. Petrucci (2009) proposed a formula to test the adequacy of this value. Therefore, the chance accuracy rate was calculated and found to be 28.22%. This value, less than 43.4%, indicates that the model is sufficiently accurate.

Discussion

Learning environments serve as the places where we bring students and competencies together. Therefore, the design of effective learning environments is crucial. Learning activities, which closely relate to the teacher's pedagogy, are powerful tools to contribute to the effectiveness of the learning environments. Based on this view, this study aims to determine the predictive factors that affect students' engagement in learning activity methods.

The first finding was that the highest rate of students' engagement belonged to game-based activity methods while the lowest belonged to technology-based. The reason for the highest engagement may stem from the nature of the learning activity method itself. According to Whitton (2012), game-based learning promotes collaboration between students and provides meaningful and exciting experiences for learners so that they can promote student engagement. In support of this, students tended to be more involved in a game-based lesson (Pinto, Jaftha, Borg, Micallef & Chircop, 2022). The reason for the lowest engagement in technology-based activities may be the activities included. They were based on coding and virtual reality. Weber and Custer (2005) reported that students found utilizing, designing, and making technology activities unattractive. Another reason may be the context of the interests of the students. To support this, Gudel, Heitzmann, and Müller (2019) reported that students had a lower interest in technology in the context of school than in leisure time. Further, the personal characteristics of the activity coordinators can affect students' engagement in the activities. In their study, Abdullah, Abu Bakar and Mahbab (2012) reported that instructors who show good moods and behave like friends could promote students' interest and engagement.

The second finding reported that the attractiveness of the activity predicted the engagement of the students. This finding is consistent with Chen and Shen's (2004) study, which stated that learning preferences and interests are the two critical factors for student engagement. Similarly, Chen and Darst (2001) reported that interest is vital in promoting students' engagement and learning behaviours. Mostly, situational interest arises from interacting with the learning environment, promoting behavioural or cognitive participation in a learning task (Kahu, Nelson & Picton, 2017). Supporting this finding, preservice teachers preferred mostly activities such as real-life applications of scientific ideas, science process skills development, and enjoyable hands-on activities. Furthermore, they justified their activity selection based on four main factors: promoting students' motivation and transfer of learning, providing meaningful understanding, and curriculum (Talanquer, Novodvorsky & Tomanek, 2010). Therefore, the results of this study, which are essential to conider motivation and interest factors for engagement in an activity, support the obtained finding.

Furthermore, the second finding revealed that increasing the attractiveness of the activity affects the probability of selecting TBA 1.75 times more, GBA 1.37 times more, and ABA 2.38 times more over CBA. One reason is that these activities are extracurricular activities. Experiencing different subject contents can attract students' interest and affect their engagement. Similarly, the other reason may be the content of the activities. For example, the calculations-based activities focused a lot on maths subjects. Therefore, the content may not motivate students to select CBA instead of TBA, GBA, and ABA. Another reason may be due to the nature of the activity methods themselves. Students tended to engage in activities that mostly allow active engagement, challenge, fun, and interaction with teachers or peers, as Attard (2013) stated. Because GBA, ABA, and TBA allow students to experience the factors they prefer, students may engage in these activities instead of CBA.

The third finding was that the activity's instructiveness predicted students' engagement in learning activity methods. According to Baber (2020), perceived learning is mainly affected by student motivation, course structure (e.g., teaching ways), and instructor knowledge. Based on this, students may think of the activities as instructive because they are interested in the content of the activity or its method. In addition, the personal characteristics of the activity coordinator may affect their engagement. To support this, the interaction between students and teachers could affect students' understanding (Ayuwanti, Marsigit & Siswoyo, 2021).

Furthermore, the third finding showed that increasing the instructiveness of the activity affects the probability of engaging in CBA 2.04 times more than TBA and 1.67 times more than ABA. Chen, Jones and Xu (2018) noted that perceived learning through collaboration is much more effective in visual learners. In this study, TBA and ABA were not based on collaborative learning and were extracurricular activities. However, in CBA, abstract concepts in the mathematics curriculum were presented through posters and materials. Since this situation increases the learning experience, it may have affected the engagement of the students. The study by Eom, Wen and Ashill (2006), which reported that the learning style is effective in perceived learning, also supports this finding.

Another important finding was that the usefulness of the activity did not predict students' engagement in learning activity methods. Interestingly, although the activity's instructiveness predicted the engagement, the benefit was ineffective. The reason may be that we do not tend to transfer what students have learnt to other contexts. The barrier to learning transfer may be that students do not see their learning as relevant to their daily lives and know how to do it due to the lack of teacher support.

The last finding showed that the target audience was another essential factor in students' engagement. Analyses indicated that elementary school students were more likely to engage in game-based, discussion, experimental, and technology-based activities in decreasing order instead of calculation-based activities when compared to undergraduates. Middle school students were 121.81 times more likely to engage in game-based activities instead of calculation-based activities when compared to undergraduates. Furthermore, the findings showed that they were likely to engage in discussion activities 45.53 times more, art-based activities 16.82 times more, experimental activities 10.70 times more, and technology-based activities 6.55 times more than calculation-based activities. In other words, middle school students' engagement in learning activity methods was game-based, discussion, art-based, experimental, and technology-based activities in decreasing order instead of calculation-based activities. Although there were similar preferences in elementary and middle school students' engagement, high school students engaged in different activity methods. Accordingly, they were 69.63 times more likely to engage in technology-based activities instead of calculation-based activities when compared to undergraduates. Besides, they were likely to engage in game-based activities 56.41 times more, discussion activities 51.43 times more, experimental activities 49.38 times more, and art-based activities 14.22 times more. The last finding pointed out differences in students' engagement in terms of the target audience. The reason may be related to the student's developmental stages. According to Piaget, high school students are in the formal operational stage, while elementary and middle school students are in the concrete operational stage. Differences in developmental stages and their effect on students' cognitive abilities may affect their engagement. For example, when considering the cognitive development characteristics of the concrete operational stage, it may be adequate to offer hands-on activities, visually enriched materials, and challenging opportunities for students. Supporting this, Johnson (2006) stated that elementary students preferred activities such as educational games, science experiments, and collaborative learning experiences because all these activities allow students to experience active engagement and fun.

The last finding pointed out that TBA was in the last order in elementary and middle school students' engagement while in the first order for high school students. Middle school students preferred smartphones or tablets for technology-based activities and considered collaborative-based digital games more useful (Gigantesco, Palumbo, Zodwarna, Cieslak, Cuscavilla, Del Re, Kossakawska & WST European Group, 2019). Therefore, their view about TBA may affect their engagement. However, Wu (2015) stated that most youth spent nearly 7-15 hours playing digital games, and that their interest may affect their engagement in TBA. Another reason may be related to the content of TBA. In one of the technology-based activities, the students experienced the use of virtual reality in various business areas. Therefore, their vocational interest may be compelling for their engagement.

Conclusion and Suggestions

The results showed that the attractiveness and instructiveness of the activity, in addition to the target audience, predicted students' engagement. Based on this, it is concluded that the methods of learning activities and some characteristics matter to promote student engagement. Therefore, teachers must consider the developmental stages of their students in designing and using instructional activities. Additionally, instructional activities, whatever the methods are, should consist of attractive elements to promote students' engagement. The findings of the study also highlight the importance of teacher-student interaction. Based on this, it is suggested that activities in or out of the classroom should promote the interaction between the student and the teacher.

This study informs educators about the factors to be considered when designing a learning environment, especially when planning instructional activities. It also emphasized which activity methods can support students' engagement in different grades. It is based on rigorous analyses that present how learning can be enhanced in formal and informal contexts.

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References

Abdullah, M. Y., Abu Bakar, N. R. & Mahbob, M. H. (2012). Student's participation in the classroom: What motivates them to speak up? *Procedia Social and Behavioral Sciences, 51*(2012), 516-522. https://doi.org/10.1016/j.sbspro.2012.08.199

Agaoglu, O. & Demir, M. (2020). The integration of 21st century skills into education: An evaluation based on activity example. *Journal of Gifted Education and Creativity, 7*(3), 105-114.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Wiley.

Anwer, P. (2019). Activity-based teaching, student motivation, and academic achievement. *Journal of Education and Educational Development, 6*(1), 154-170.

Arcagok, S. (2021). The impact of game-based teaching practices in different curricula on academic achievement. *International Online Journal of Education and Teaching (IOJET), 8*(2). 778–796.

Attard, C. (2013). "If I had to pick any subject, it wouldn't be maths": Foundations for engagement with mathematics in the middle years. *Mathematics Education Research Journal,13*, 569–587. https://doi.org/10.1007/s13394-013-0081-8

Ayuwanti, I., Marsigit, Siswoyo, D. (2021). Teacher-student interaction in mathematics learning. *International Journal of Evaluation and Research in Education, 10*(2), 660-667. https://doi.org/10.11591/ijere.v10i2.21184

Baber, H. (2020). Determinants of students' perceived learning outcome and satisfaction in online learning during the pandemic of COVID 19. *Journal of Education and e-Learning Research, 7*(8), 285–292. https://doi.org/10.20448/journal.509.2020.73.285.292

Cayubit, R.F.O. (2022). Why learning environment matters? An analysis of how the learning environment influences the academic motivation, learning strategies, and engagement of college students. *Learning Environments Research, 25*, 581–599. https://doi.org/10.1007/s10984-021-09382-x

Chen, A. & Darst, P.W. (2001). Situational interest in physical education: A function of learning task design. *Research Quarterly for Exercise and Sport, 72*(2), 150-164.

Chen, C., Jones, K. & Xu, S. (2018). The association between students' style of learning preferences, social presence, collaborative learning and learning outcomes. *Journal of Educators Online, 15*(1). https://eric.ed.gov/?id=EJ1168958

Chen, A. & Shen, B. (2004). A web of achieving in physical education: Goals, interest, outside-school activity and learning. *Learning and Individual Differences, 14*, 169-182

Danipog, L. D. & Ferido, B. M. (2011). Using art-based chemistry activities to improve students' conceptual understanding of chemistry. *Journal of Chemical Education, 88*(12), 1610–1615.

da Silva Clarindo, C. B., Miller, S. & Kohle, E. C. (2020). Learning activity as a means of developing theoretical thinking capacities. *Frontiers in Psychology, 11*, 1-11. https://doi.org/10.3389/fpsyg.2020.603753

Eom, S. B., Wen, H. J. & Ashill, N. (2006). The determinants of students' perceived learning outcomes and satisfaction in university online education: An empirical investigation. *Decision Sciences Journal of Innovative Education, 4*(2), 215–235.

Fernandez-García, C. M., Maulana, R., Inda-Caro, M., Helms-Lorenz, M., & Garcia-Pérez, O. (2019). Student perceptions of secondary education teaching effectiveness: General profile, the role of personal domains of DREEM, and educational level. *Frontiers in Psychology, 10*, 1-11. https://doi.org/10.3389/fpsyg.2019.00533

Field, A. (2009). *Discovering statistics using SPSS* (3rd Ed.). London: Sage Publications.

Fraenkel, J. R. & Wallen, N. E. (2009). *How to design and evaluate research in education* (7th Ed.). New York: McGraw-Hill Companies.

Gericke, N., Högström, P. & Wallin, J. (2022). A systematic review of research on laboratory work in secondary school. *Studies in Science Education*, https://doi.org/10.1080/03057267.2022.2090125

Gigantesco, A., Palumbo, G., Zadworna Cieslak, M., Cascavilla, I., Del Re, D., Kossakowska, K. & WST European Group (2019). An international study of middle school students' preferences about digital interactive education activities for promoting psychological well-being and mental health. *Annali dell'Istituto Superiore di Sanità, 55*(2), 108-119. https://doi.org/10.4415/ANN_19_02_02

Green, V. N. (2012). *Effects of classroom discussion on student performance and confidence in the science classroom*. (Unpublished master's thesis). Montana State University.

Gudel, K., Heitzmann, A. & Müller, A. (2019). Self-efficacy and (vocational) interest in technology and design: an empirical study in seventh and eighth-grade classrooms. *International Journal of Technology and Design Education, 29*, 1053-1081. https://doi.org/10.1007/s10798-018-9475-y

Gunes, G., Arikan, A. & Cetin, T. (2020). Analyzing the effect of authentic learning activities on achievement in social studies and attitudes towards geographic information system (GIS). *Participatory Educational Research, 7(*3), 247-264. http://dx.doi.org/10.17275/per.20.45.7.3

Hanrahan, M. (1998). The effect of learning environment factors on students' motivation and learning. *International Journal of Science Education, 20*(6), 737–753.

Inda-Caro, M., Maulana, R., Fernandez-Garcia, C. M., Peña-Calvo, J. V., Rodriguez-Menendez, M. D. C. & Helms-Lorenz, M. (2019). Validating a model of effective teaching behavior and student engagement: Perspectives from Spanish students.

Learning Environments Research, 22(2), 229–251. https://doi.org/10.1080/00313831.2019.1577754

Johnson, L. M. (2006). Elementary school students' learning preferences and the classroom learning environments: Implications for educational practice and policy. *The Journal of Negro Education, 75*(3), 506–518. https://www.jstor.org/stable/40026818

Kahu, E., Nelson, K. & Picton, C. (2017). Student interest is a key driver of engagement for first-year students. *Student Success Journal, 8*(2), 55–66. https://doi.org/10.5204/ssj.v8i2.379

Karagoz, Y. (2017). *SPPS ve AMOS uygulamalı nitel, nicel, karma bilimsel araştırma yöntemleri ve yayın etiği* [SPSS and AMOS applied qualitative, quantitative, mixed scientific research methods and publication ethics]. Ankara: Nobel Yayınevi.

Karns, G. L. (2005). An Update of marketing student perceptions of learning activities: Structure, preferences, and effectiveness. *Journal of Marketing Education, 27*(2), 163–171. https://doi.org/10.1177/0273475305276641

Kasalak, İ. & Altun, A. (2020). Effects of robotic coding activities on the effectiveness of secondary school students' self-efficacy for coding. *Elementary Education Online, 19*(4), 2171–2182. https://doi.org/10.17051/ilkonline.2020.763834

Malik, R. H. & Rizvi, A. A. (2018). Effect of classroom learning environment on students' academic achievement in mathematics at secondary level. *Bulletin of Education and Research, 40*(2), 207-218.

Nam, E. & Seong, M. (2020). Teaching activities and students' preferences in integrated college English reading and writing classes. *English Teaching, 75*(2), 69–91. https://doi.org/10.15858/engtea.75.2.202006.69

Nasrullah, S., Khan, M. S., Matiullah, Kamal, S. & Khan, I. U. (2017). Effect of classroom activities in teaching-learning process at primary level. *Science International (Lahore), 29*(3), 691-695.

Oncu, S. & Bichelmeyer, B. A. (2021). Instructional practices affecting learner engagement in blended learning environments. *Participatory Educational Research (PER), 8*(3), 210-226. http://dx.doi.org/10.17275/per.21.62.8.3

Opdenakker, M.C. & Minnaert, A. (2011). Relationship between learning environment characteristics and academic engagement. *Psychological Reports, 109*(1), 259–284. https://doi.org/10.2466/09.10.11.PR0.109.4.259-284

Petrucci, C. J. (2009). A primer for social worker researchers on how to conduct a multinomial logistic regression. *Journal of Social Service Research, 35*(2), 193–205. https://doi.org/10.1080/01488370802678983

Pinto, F. C. M., Jaftha, N., Borg, S., Micallef, Z. & Chircop, T.(2022). Students' learning and gaming preferences and their expectations of gamification. *MCAST Journal of Applied Research & Practice, 6*(1), 60–78.

Qian, M & Clark, K. R. (2016). Game-based learning and 21st century skills: A review of recent research. *Computers in Human Behavior, 63*, 50–58. http://dx.doi.org/10.1016/j.chb.2016.05.023

Sanchez, N. S. (2017). Discovering students' preference for classroom activities and teachers' frequency of activity use. *Colombian Applied Linguistics Journal, 19*(1), 51-66. http://dx.doi.org/10.14483/calj.v19n1.9292

Shana, Z. & Abulibdeh, E. S. (2020). Science practical work and its impact on students' science achievement. *Journal of Technology and Science Education JOTSE, 10*(2), 199-215. https://doi.org/10.3926/jotse.888

Simonds, T. A. & Brock, B. L. (2014). Relationship between age, experience, and student preference for types of learning activities in online courses. *Journal of Educators Online, 11*(1), 1–19.

Staples, A. F., Larson, L. R., Worsley, T., Green, G. T. & Carroll, J. P. (2019). Effects of an art-based environmental education camp program on the environmental attitudes and awareness of diverse youth. *Journal of Environmental Education, 50*(3), 208–222. https://doi.org/10.1080/00958964.2019.1629382

Swarat, S., Ortony, A. & Revelle, W. (2012). Activity matters: Understanding student interest in school science. *Journal of Research in Science Teaching, 49*(4), 515–537. https://doi.org/10.1002/tea.21010

Tabachnick, B. & Fidell, L. S. (2007). *Using multivariate statistics* (5th Ed.). New York: Allyn and Bacon

Talanquer, V., Novodvorsky, I. & Tomanek, D. (2010). Factors influencing entering teacher candidates' preferences for instructional activities: A glimpse into their orientations towards teaching, *International Journal of Science Education, 32*(10), 1389-1406. http://dx.doi.org/10.1080/09500690903019572

Taner Derman, M., Şahin Zeteroğlu, E., Ergişi Birgül, A. (2020). The effect of play-based math activities on different areas of development in children 48 to 60 months of age. *SAGE Open, 10*(2), 1-12. https://doi.org/10.1177/2158244020919531

Thomas, C. L., Pavlechko, G. M. & Cassady, J. C. (2019). An examination of the mediating role of learning space design on the relation between instructor effectiveness and student engagement. *Learning Environments Research, 22*, 117-131. https://doi.org/10.1007/s10984-018-9270-4

Townsend, L. A. (2012). *The effects of laboratory-based activities on student attitudes toward science*. (Unpublished master's thesis). Montana State University. https://scholarworks.montana.edu/xmlui/handle/1/2435

Usman, Y. D. & Madudili, C. G. (2019). *Evaluation of the effect of learning environment on student's academic performance in Nigeria*. Online Submission. Retrieved by https://eric.ed.gov/?id=ED602097

Weber, K. & Custer, R. (2005). Gender-based preferences toward technology education content, activities, and instructional methods. *Journal of Technology Education, 16*(2), 55-71.

Whitton, N. (2012). The place of game-based learning in an age of austerity. *The Electronic Journal of e-Learning (EJEL), 10*(2), 249–256.

Wu, M. L. (2015). *Teachers' experiences, attitudes, self-efficacy, and perceived barriers to the use of digital game-based learning: A survey study through the lens of a typology of educational digital games*. (Unpublished doctoral thesis). Michigan State University. https://d.lib.msu.edu/etd/3754

Yildiz, T. & Seferoglu, S. S. (2021). The effect of robotic programming on coding attitude and computational thinking toward self-efficacy perception. *Journal of Learning and Teaching in Digital Age, 6*(2), 101-116.

Zhu, D. (2012). Using games to improve students' communicative ability. *Journal of Language Teaching and Research, 3*(4), 801–805.