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Assessment of Solid Waste Management at Source in Compliance with Guidelines

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ABSTRACT

Solid waste management poses a big challenge for many urban households, especially in developing countries. Overcrowding and informal settlements have emerged with illegal and indiscriminate waste disposal. Guidelines for proper management of solid waste are least observed at household level in such settings. The study was to assess solid waste management at source in compliance with guidelines among residents of Kawempe municipality, Kampala district. It was descriptive and analytical cross-sectional study design, where 385 household heads and local leaders were interviewed using questionnaires and interview guides. Only 37.9% of households complied with guidelines for solid waste management at source. Factors of waste management practices were waste reduction (p<.005), separation (p<.001), reuse (p<.001) and composting (p<.027). Determinants such as gender (p<.007), marital status (p<.016), educational level (p<.00), occupation (p<.007), household size (p<.025), medium of community sensitization (p<.00), enforcement of bi-laws (p<.005), type of waste generated (p<0.00) and waste storage method (p < .009) were implicated. Conclusively, compliance with guidelines in the management of household solid waste at source was still very low within the city.

Keywords: Compliance, Guidelines, Kampala, Solid waste management, Uganda

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INTRODUCTION

Solid waste management (SWM) poses a big challenge for many urban households, municipalities and cities at large especially in the low income countries as a result of increasing urbanization (Mukama et al., 2016). It is projected that Sub-Saharan Africa will be the world's fastest-growing region for waste generation by 2050 due to increasing urbanization, yet it is poorly planned with inefficient solid wastes management strategies (Bello et al., 2016 and Aryampa et al., 2019). In Kampala city, about 54% of the population in live in crowded and slum areas located mostly in low-lying zones and in wetlands with inevitable development of unplanned informal settlements and consequently illegal and indiscriminate waste disposal methods. These poor waste management strategies predispose households to environmental and health hazards including waterborne diseases such as typhoid, diarrhea, hepatitis and respiratory ailments (Cruvinel et al., 2019). Household solid waste include refuse of day-to-day leaving mainly organic biodegradable wastes, including peelings from raw foods, fruit and vegetables, food remains and leaves, paper, textile and yard waste (Komakech et al., 2014), and partially degradable waste like disposable napkins, wood and sanitary residues, and non-degradable waste including plastics, leather, rubbers, glass, metal and electronic waste.

Most developing economies in low-income countries like Uganda have refined policies for SWM but residents reluctantly comply due to lack of enforcement of the policies/by-Laws and inadequate public education and awareness (Al-Khatib et al., 2009; Al-Khatib et al., 2010; McAllister, 2015). A study by Wadehra and Mishra (2017) in Delhi revealed a clear disconnect between the formulated household SMW guidelines by the authorities, the information being delivered to households and their practice in compliance with the guidelines. Whereas the guidelines and the knowledge of negative effects should be enabling the community members to reduce the generation of waste at source and to ensure proper disposal, individual households waste disposal practices largely don't conform to guidelines (Ishfaq et al., 2021).

Purpose of the research

The Study had the following specific objectives

(i) To investigate the solid waste management practices at source associated with compliance with guidelines among residents of Kawempe Division, Kampala District
(ii) To establish socio-demographic determinants of solid waste management at source in compliance with guidelines among residents of Kawempe division Kampala District
(iii) To determine the attitudes about solid waste management at source in compliance with guidelines among residents of Kawempe division Kampala District
(iv) To examine the barriers of solid waste management at source affecting compliance with guidelines among residents of Kawempe Division, Kampala District

METHOD

Study Design

A descriptive and analytical cross-sectional study design was used with both quantitative and qualitative techniques, hence a mixed methods study.

Study Population

All households of Kawempe division preferably the heads of the respective households and the key informants were chosen among local council leaders.

Sample Size Determination

Cochran formula for large populations (Cochran, 1977) was used:

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where: n_0 = the required sample size

Z^2 = the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, 95% in this study) = 1.96,

e = the level of precision (error), set at 5% or 0.05 for this study,

p = estimated proportion of compliance with guidelines among households. We used a statistically conservative prevalence of 50% compliance with guidelines.

q = 1-p.

Thus, $\boldsymbol{n_0}$ = 385 households heads

Sampling Technique

The sample size was distributed proportionately across all the Parishes in Division. The number of households in each of the Parishes were obtained from the Division offices and the sample from each parish was expressed as a proportion of the total study sample to obtain the number of respondents from each parish. The sampling interval for each parish was got by dividing the number of households by the sample from that particular parish. Systematic random sampling was then used where the pre-determined number of respondents per parish was attained. First respondent from each parish was selected randomly.

Data Collection Tools and Methods

A researcher-administered semi-structured questionnaire, an observational check list and interview guides for key informants were used. Both open and closed ended questions were included.

Data Entry, Analysis and Presentation

For quantitative data, the collected data were entered into Microsoft office excel for editing and cleaning then into STATA for analysis. Descriptive statistics was analyzed and presented in terms of frequencies and percentages in tables. The Chi-square test was used to determine the association between the two variables through bivariate analysis while odds ratios was used for the measure of association between the predictor and outcome variables for inferential statistics. Qualitative data were coded and transcribed, generating themes and sub-themes that were analyzed.

RESULTS

Participants

Table 1: Socio-demographic characteristics of the participants

Socio-demographic Variables		*f*	%
Age in years	▪ <30	191	49.6
	▪ >=30	194	50.4
Gender	▪ Female	260	67.5
	▪ Male	125	32.5
Marital status	▪ Divorced/separated/widowed	91	23.6
	▪ Married/cohabiting	161	41.8
	▪ Others	1	0.3
	▪ Single	132	34.3
Highest level of education	▪ Primary	76	19.7
	▪ Secondary	200	52
	▪ Tertiary	104	27
	▪ Never schooled	5	1.3
Religion	▪ Born again	82	21.3
	▪ Catholic	85	22.1
	▪ Muslim	103	26.7
	▪ Others	8	2.0
	▪ Protestant	108	28.1
Number of people living in the house	▪ <5	230	59.7
	▪ 5-10	150	39
	▪ >10	5	1.3
Duration lived in the place	▪ < 1 year	71	18.4
	▪ 1-5years	180	46.8
	▪ 6-10 years	70	18.2
	▪ >10 years	64	16.6

Table 1 summarizes the socio-demographic characteristics. Majority of the respondents (50.4%), were aged 30 years above, 67.5% were female and 41.8% were either married or cohabiting. Most participants (52%) were of secondary level of education and only 1.3% had never attained school education. 28.1% of respondents were of the protestant religion, 59.7% lived with families of less than five and 46.8% had been residents for one to five years.

Solid Waste Management Practices Associated with Compliance with Guidelines

Compliance with guidelines was measured by scoring the respondent's solid waste management practices against each of the following six standards; waste reduction, separation, re-use, recycling, composting and responsible disposal, table 2. Bivariate analysis was made between the practice variable and compliance with guidelines. The chi square test was done to obtain crude odds ratios between the independent variables and the outcome variable.

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STEAM Eğitimi Araştırmaları Derneği

Statistically significant independent variables at bivariate analysis were then subjected to a multi-variable logistics regression model to test for their significance, table 3.

Table 2. Solid waste management practices in compliance with guidelines

Waste Management Variables	Compliance with Guidelines: Complied (146)	Compliance with Guidelines: Didn't comply (239)	Total	COR (95% CI: L – U)	*p -value*
Taking shopping basket or bag when shopping					
▪ Always	97(66.4%)	149(62.3%)	246	1.0	**0.005**
▪ Most of the times	34(23.3%)	35(14.6%)	69	0.5(0.3-1)	
▪ Never	0(0%)	2(0.8%)	2	0.4(0.2-0.8)	
▪ Rarely	1(0.7%)	12(5%)	13	4.1(0.5-34.4)	
▪ Sometimes	14(9.6%)	41(17.2%)	55		
Do separate solid waste you generate at home					
▪ No	92(63%)	189(79.1%)	281	1.0	**0.001**
▪ Yes	54(37%)	50(20.9%)	104	2.2(1.4-3.5)	
Reuse of solid waste generated at home					
▪ No	16(11%)	60(25.1%)	76	1.0	**0.001**
▪ Yes	133(89%)	176(74.9%)	309	2.7(1.5-4.9)	
If yes, which of solid waste					
▪ Cardboard, papers and food leftovers	56(42.7%)	79(44.4%)	135	1.0	**0.002**
▪ Food leftover	10(7.6%)	8(4.5%)	18	0.9(0.3-2.4)	
▪ Food leftover and bottles	58(44.3%)	59(33.2%)	117	0.3(0.1-0.7)	
▪ Plastics bottles	6(4.6%)	31(17.4%)	37	0.2(0.1-0.5)	
▪ Plastics and glasses	1(0.8%)	1(0.6%)	2		
Do you recycle solid waste					
▪ No	141(96.6%)	235(98.3%)	376	1.0	0.310
▪ Yes	5(3.4%)	4(1.7%)	9	2.1(0.5-7.9)	
Do you compost some of your solid waste					
▪ No	127(87%)	224(93.7%)	351	1.0	**0.027**
▪ Yes	19(13%)	15(6.3%)	34	2.2(1.1-4.5)	
If no, what are the reasons					
▪ I don't know how to compost	26(21.0%)	59(26.7%)	85	1.0	**0.040**
▪ Lack space	27(21.0%)	33(14.0%)	60	0.6(0.3-1.6)	
▪ Lack space and I don't know to compost	13(10.5%)	47(21.3%)	60	1.8(0.7-4.1)	
▪ Lack of space and no nearby composing facility	36(29.0%)	48(21.7%)	84	0.5(1.3-0.6)	
▪ Lack of space and not interested in composting	9(7.3%)	18(8.1%)	27		

▪ No nearby composting facility	17(11.3%)	18(8.1%)	35		
Is there solid waste whose final disposal is within your home					
▪ No	43(29.5%)	102(42.7%)	145	1.0	**0.010**
▪ Yes	103(70.6%)	137(57.3%)	240	1.7(1.2-2.8)	
If yes, what kind of waste					
▪ Food remains	17(16.7%)	18(13%)	35	1.0	**<0.0001**
▪ Food remains and plastic waste	3(2.9%)	11(8.0%)	14	0.1(0.02-0.02)	
▪ Garden yard waste	5(4.9%)	17(12.3%)	22	0.1(0.1-0.69)	
▪ Garden yard and food remains	76(74.5%)	75(54.4%)	151	0.01(0.01-0.5)	
▪ Plastics waste	1(1.0%)	17(12.3%)	18		
How do you carry out final dispersal					
▪ Open burning	36(35.0%)	63(46.3%)	99	1.0	**0.005**
▪ Use as animal feed	5(4.9%)	15(11%)	20	1.7(0.9-2.9)	
▪ Use as animal feed and open burning	7(6.8%)	6(4.4%)	13	1.2(0.6-2.3)	
▪ Use animal and poultry feeds	20(19.4%)	9(6.6%)	29	0.1(0.1-1)	
▪ Use as poultry feed					
▪ Use as poultry feeds and open	13(12.6%)	17(12.5%)	30	0.6(0.3-1.3)	
burning	16(15.5%)	25(18.4%)	41		
▪ Others					
	6(5.8%)	2(0.7%)	8		
Do u have access to solid waste collection service at home					
▪ No	62(42.5%)	74(31.0%)	136	1.0(0.4-0.9)	**0.028**
▪ Yes	84(57.5%)	165(69.0%)	249		

Study findings indicate that only 146 (37.9%) of the households complied with guidelines in managing their solid waste at source. From table 4 above, solid waste reduction ($p<0.005$), separation ($p<0.001$), re-use ($p<0.001$), composting ($p<0.002$) and responsible disposal ($p<0.027$) were all statistically significant factors of household solid waste management practices.

Majority of participants,63.9%, always took a shopping bag while going shopping but only 39.4% of these complied with general guidelines. 0.5% never carried a shopping bag while going shopping. Most of the households (73%) did not practice solid waste separation at source. Those who separated their waste were 2.2 times more likely to comply with guidelines compared with those who did not (Crude odds ratio (COR): 2.2, CI: 1.4-3.5). 80.3% of participants practiced re-use of some of the generated solid waste although, 57% of these failed to comply with general guidelines. Those who practiced re-use of some waste were 2.7 times more likely to comply with guidelines compared with those who did not practice (COR: 2.7, CI: 1.5-4.9).

Also, only 8.8% of households practice composting of some of the solid waste and most of these (55.9%) complied with general guidelines. Majority of those who did not practice composting (24.6%, $p<0.040$), did not have knowledge of solid waste composting. Although 41.1% of households practiced open burning as a solid waste disposal method, those who used the waste as animal feeds were 1.7 times more likely to comply with guidelines compared with those who practiced open burning (COR: 1.7, CI: 0.9-2.9, $p<0.005$). See table 3 for details.

Table 3. Multivariate Logistics Regression Showing Compliance with Guidelines

Variable	Adjusted odd ratios	95% CI L – U	*p- value*
Gender			
▪ Female	1.0		
▪ Male	1.9	1.21-3.04	0.006
Highest level of education			
▪ Primary	1.0		
▪ Secondary	1.3	0.13-12.04	0.839
▪ Tertiary	1.9	0.21-17.58	0.561
▪ Never schooled	5.9	0.64-54.7	0.118
Taking shopping basket or bag when shopping			
▪ Always	1.0		
▪ Most of the times	1.9	0.99-3.68	0.055
▪ Never	2.8	1.32-6.14	0.008
▪ Rarely	N/A		0.999
▪ Sometimes	0.2	0.01-2.05	0.194
Do separate solid waste you generate at home			
▪ No	1.0		
▪ Yes	0.4	0.28-0.71	0.001
Re-use of solid waste generated at home			
▪ No	1.0		
▪ Yes	0.4	0.21-0.68	0.001

Socio-demographic determinants of Solid Waste Management in Compliance with Guidelines

Determinants of compliance with guidelines in the management of solid waste at household level were established by asking related questions to participants and examining their socio-demographic characteristics. After entering responses in STATA, bivariate analysis was done, table 4.

Table 4. Socio-demographic determinants of solid waste management in compliance with guidelines

Socio-demographic Variables	Compliance with guidelines: Complied (146)	Didn't comply (239)	Total	COR (95% CI: L - U)	*p-value*
Age (years)					
▪ <30	63(43.2%)	128(53.6%)	191	1.0	0.059
▪ >=30	83(56.9%)	111(46.4%)	194	1.5(1-2.3)	
Gender					
▪ Female	111(76.0%)	149(62.3%)	260	1.0	**0.007**
▪ Male	35(24.0%)	90(37.7%)	125	0.5(0.3-0.8)	
Marital status					
▪ Divorced/separated/ widowed	39(26.7%)	52(21.8%)	91	1.0	**0.016**
▪ Married/cohabiting	70(48.0%)	91(38.1%)	161	0.5(0.3-0.9)	
▪ Others	0(0.0%)	1(0.4%)	1	0.5(0.3-0.8)	
▪ Single	37(25.3%)	95(39.8%)	132		
Highest level of education					
▪ Primary	18(12.3%)	58(24.3%)	76	1.0	**<0.0001**
▪ Secondary	65(44.5%)	135(56.5%)	200	5.9(0.6-54.7)	
▪ Tertiary	62(42.5%)	42(17.6%)	104	4.7(2.5-9.2)	
▪ Never	1(0.7%)	4(1.7%)	5	3.1(1.9-5.1)	
Major occupation					
▪ Business	78(53.4%)	140(58.6%)	218	1.0	**0.007**
▪ Causal occupational	14(9.6%)	25(10.5%)	39	0.5(0.2-1.1)	
▪ Farming	12(8.2%)	11(4.6%)	23	0.5(0.2-1.3)	
▪ Others	2(1.4%)	7(2.9%)	9	0.3(0.1-0.7)	
▪ Professional	31(21.2%)	24(10.0%)	55	0.9(0.2-5.6)	
▪ Student	9(6.2%)	32(13.4%)	41	0.2(0.1-0.5)	
Number of people living in the house					
▪ <5	75(51.4%)	155(64.9%)	230	1.0	**0.025**
▪ 5-10	69(47.3%)	81(33.9%)	150	1.8(1.2-2.7)	
▪ >10	2(1.4%)	3(1.3%)	5	1.3(0.2-7.9)	
If yes, how					
▪ Over radio and television	82(56.6%)	64(26.9%)	146	1.0	**<0.0001**
▪ Over radio	60(41.4%)	150(63.0%)	210	0.2(0.01-3.3)	
▪ Over television	4(2.1%)	19(8.0%)	23	0.1(0.04-0.4)	
▪ Others	0(0.0%)	6(2.1%)	6	0.4(0.1-1.4)	
Enforcement of proper solid waste management by leaders					

▪ Once a week	52(35.6%)	88(36.8%)	14	1.0	**0.005**
▪ Once a month	76(52.1%)	92(38.5%)	0	0.7(1.3-0.4)	
▪ After every three	8(5.5%)	39(16.3%)	16	0.2(0.01-2.3)	
months			8		
▪ After every six	3(2.1%)	4(1.7%)	47	0.4(0.1-1.2)	
months					
▪ Have never seen	2(1.4%)	1(0.4%)	7	0.6(0.2-1.6)	
them enforce					
▪ Others	5(3.4%)	15(6.3%)	3		
			20		
Type of solid waste					
▪ Garden yard and	1(0.7%)	16(6.7%)	17	1.0	**<0.00**
peelings					**01**
▪ Plastics, garden	99(67.8%)	113(47.3%)	21	6.7(0.9-1.9)	
yard, peelings and			2		
food waste					
▪ Plastics	2(1.4%)	15(6.3%)		0.5(0.3-0.7)	
▪ Plastics and paper	0(0.0%)	5(2.1%)	17		
▪ Plastic, paper, food	4(2.7%)	12(5.0%)	5		
waste			16		
▪ Plastics, garden	40(27.4%)	78(32.6%)			
yard and peelings			11		
			8		
How do you store solid waste					
▪ Plastic bags	67(45.9%)	154(64.4%)	22	1.0	**0.009**
▪ Plastic bags and	7(4.8%)	8(3.4%)	1	2.1(0.5-9)	
others	15(10.3%)	11(4.6%)	15	3.2(0.7-13.6)	
▪ Plastic bag, waste			26		
bucket and others	3(2.1%)	2(0.8%)			
▪ Plastic bag and			5		
open pile outside	5(3.4%)	3(1.3%)			
▪ Waste basket and			8		
open container	1(0.7%)	2(0.8%)			
▪ Plastic bags and			3		
cardboard box	48(32.9%)	59(24.7%)			
▪ Others			10		
			7		

From table 4, gender ($p < 0.007$), marital status ($p < 0.016$), highest level of education ($p<0.0001$), major occupation ($p<0.007$), number of people living in the house ($p<0.025$), medium through which households were educated about proper solid waste management ($p<0.0001$), enforcement of proper of bi-laws ($p < 0.005$), type of solid waste generated ($p<0.0001$) and solid waste storage method ($p<0.009$) were all significant determinants. Males were 0.5 times less likely to comply with guidelines compared with females (COR: 0.5, CI: 0.3-0.8). Most of the respondents were either married or cohabiting and that being of this marital status had 0.5 times less chances of complying with guidelines (COR: 0.5, CI: 0.3-0.9). Being of secondary, tertiary and the never schooled group, had 5.9, 4.7 and 3.1 times more chances of complying with guidelines compared with primary level of education respectively (COR: 5.9, CI (0.6-54.7); COR: 4.7, CI (2.5-9.2); COR: 3.1, CI (1.9-5.1)). Households with 5-10 and those with more than 10 people were 1.8 and 1.3 times more likely to comply with guidelines compared with households with less than five people (COR: 1.8, CI (1.2-2.7); COR: 1.3, CI (0.2-7.9)).

From key informant interviews presence of bi-laws was a determinant. One key informant said,

> *"[…] we held several community meetings to deliberate on solid waste management and came up with bi-laws which our members owned and are happy to abide by: for example, every household is required to have a sac or polythene bag to store their solid waste before the truck picks the waste […]".*

Attitudes of Participants about Household Solid Waste Management in Compliance With Guidelines

Attitudes were examined and scored on a Likert scale with highest score of five, for 'very appropriate', and lowest score of one, for 'very inappropriate' attitudes. Respondents who scored an average of 4 and above were considered to have enabling attitudes to comply with guidelines, table 5.

Majority of households (62.5%,) indicated that it was appropriate to carry a shopping bag whenever they went shopping, and only one respondent (0.3%) thought that it was very inappropriate. 53.8% indicated that it was appropriate to recycle. For the rest, majority thought it was not so appropriate to separate (49.9%), re-use (53.7%) and compost waste (57.1%,) respectively. Hence, the only practices in which participants had enabling attitudes with their mean score close to 4 were; waste reduction, with 64.6% responses scoring a mean of approximately 4 and waste recycling (65.2%).

Table 5. Attitudes of Households about Compliance with Guidelines

Attitudes	Very appropria te-ate	Appropria te-ate	Not so appropriate-ate	Inappropr iate	Very inappropri ate-ate	Mean (SD)
▪ Attitudes about taking a shopping bag when you go shopping	8(2.1)	240(62.5)	127(33.1)	8(2.1)	1(0.3)	3.6(0.6)
▪ Attitudes about solid waste separation	16(4.2)	170(44.4)	191(49.9)	6(1.6)	0(0)	3.5(0.6)
▪ Attitudes about re-use of some solid waste	5(1.3)	160(41.9)	205(53.7)	12(3.1)	0(0)	3.4(0.6)
▪ Attitudes about recycling	44(11.4)	207(53.8)	122(31.7)	12(3.1)	0(0)	3.7(0.7)
▪ Attitudes about composting solid waste	2(0.5)	76(19.7)	220(57.1)	73(19)	14(3.6)	2.9(0.7)

Other Barriers of Solid Waste Management at Source Affecting Compliance with Guidelines

Barriers were examined by asking related questions to households, and interviews with key informants who were local council leaders

For the key informant interviews, an interview guide and a mobile phone recorder were used. Codes were generated from which themes emerged and among others, that of barriers: Migrations, both rural-urban and within the city and illegal dumping was a significant challenge to household solid waste management in the city.

Three of the respondents expressed concerns about lack of space to designate as official dump sites which encouraged some individuals to illegally dump waste. All four (4) respondents reported challenges of internal migrations in that some new migrants usually come with varying practices and attitudes towards solid waste management and that it would take them some time to adapt to the community bi-laws. A respondent said:

> *"[…] our community is very congested that even households lack where to temporarily store their waste which sometimes forces them to just throw their wastes anywhere, especially when the KCCA truck spends more than three days without coming to pick the waste […]"*

Barriers to practicing composting of some of the solid waste statistically was significant ($p<0.04$). Lack of space, knowledge of how to compost and nearby composting facility were among the barriers cited by households.

DISCUSSION

Solid Waste Management Practices at Source Associated with Compliance with Guidelines

This study found that only 37.9% of the participants practiced household solid waste management in compliance with guidelines, comparable to findings by Ssemugabo et al. (2020) in which only 41.3% of the households exhibited proper waste management practices. 63.9% of households practiced waste reduction and 80.3% re-use, 12.1% practiced responsible disposal but 41.2% irresponsibly burnt waste. This finding is comparable to Aisa (2011) study in which 71% of households practiced waste reuse, 57.9% open dumping. Most households (72.9%) did not segregate their solid waste, a situation similar to the one in Ssemugabo et al. (2020) study in which 78.8% households did not segregate their waste.

Socio-demographic Determinants of Solid Waste Management in Compliance with Guidelines

Findings from this study revealed that gender ($p<0.007$), marital status ($p<0.016$) highest education level of the participants ($p<0.0001$), major occupation ($p<0.007$) and number of people living in the household were the significant demographic determinants of compliance with guidelines in the management of household solid waste. Similar determinants were revealed in studies by studies by (Adzawla, et al., 2019; Banga, 2011; Ashenafi, 2011; Longe et al., 2009 and Abebaw, 2008) that indicate that female participants were more likely to comply with guidelines especially on solid waste separation than males and a combination of factors including, family size, age and education of the head of the household determined compliance.

Attitudes About Solid Waste Management at Source in Compliance with Guidelines

Study findings show that the only practices with enabling attitudes were waste reduction, 64.6%, and waste recycling (65.2%), both with mean score 4. Most waste management practices received a 'not so appropriate attitude', which was not enabling compliance with guidelines.

These findings are consistent with those from a study by Banga (2011), that revealed that about 60% of respondents had negative attitude and not in support of waste segregation or recycling and majority not bothered about dumping (Blair, 2010). On the contrary, a study by Mukama et al. (2016) in Kampala slums found a high percentage of respondents indicating willingness to segregate (76.6%) and compost (54.9%) solid wastes.

Other Barriers of Solid Waste Management at Source in Compliance with Guidelines

Findings from this study show that major barriers to compliance with guidelines in household solid waste management from key informant interviews were; lack of awareness, space, infrastructural (poor housing and congested settlements), technical (inability to segregate), irregularities in waste collection and rampant internal migrations. Among the studied practices, barriers to composting were statistically significant ($p<0.040$): 24.2% of the respondents did not know how to compost, 16.6% lacked space, 24.55% lacked both space and knowledge of composting. This finding agrees with that of McAllister (2015) that found out that inadequate education and awareness about proper solid waste management led to irresponsible practices that encourage noncompliance with solid waste management reforms and guidelines. Mamady (2016), noted that majority of respondents (53.7%) whose residence was in unplanned areas mainly practiced open dumping. Another study by Nachalida et al., (2017) observed that irregularities in waste collection by authorities or private waste collectors adds to the barriers in that households who manage to sort their waste in bins get stuck with it for days or weeks which compels them to dump illegally.

CONCLUSION

Compliance with guidelines in the management of household solid waste at source is still very low even in a municipality within the capital city and yet, proper practice of such basic social actions is very essential for the transformation of lives of the city dwellers. Non-compliance with guidelines leads to poor solid waste management which has been associated with diseases of unhygienic conditions like Cholera and environmental degradation through water and air pollution with consequent reduction in the biodiversity. This reduces the quality of life of the residents affecting their social and economic productivity due to ill health, and hence a vicious cycle of poverty. On the other hand, for a developing city like Kampala, residents scoring low on basic social skills, delays transition into a modern city. This deters potential foreign investments in the city and reduces foreign exchange and earnings, and ultimately affects national development.

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CONTRIBUTORSHIP

The authors equally contributed to the authorship of this manuscript, ranging from conceptualization and design to final approval for publication.

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DECLARATIONS

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Conflict of Interest Disclosure

The authors declare no conflict of interest.

Consent for Publication

The authors do consent for publication of this work.

Data Availability

All data related to the study is available with the corresponding author and can be accessed on reasonable request.

Ethical Approval

The required country ethical approval for the study was sought. Uganda Martyrs University Research Ethics Committee approved the study. All other ethical requirements in research with human subjects have been adhered to, including but not limited to confidentiality, informed consent and voluntary participation.

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Investigation of Mobile Learning Readiness Levels of Gifted Students and Middle School Students with Normal Abilities

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ABSTRACT

In this study aimed to examine the mobile learning readiness levels of special talents and normally developing secondary school students. As a quantitative research method, correlational survey methods were used for the research. In the study, 176 gifted students secondary school students studying at the Science and Art Center (BİLSEM) and 170 students with normal development and attending secondary school participated. In total, 346 students were included in the study. Data were collected with the 'Mobile Learning Readiness Scale'. This scale has three sub-dimensions; mobile learning self-efficacy, optimism, and self-directed learning. The findings show that all students' mobile learning readiness levels are high on average. The data was analyzed through using Statistical Package for Social Sciences (SPSS 21.0) program. According to the results of the analysis of the mobile learning readiness levels of the gifted students, a significant difference was found compared to the students with normal development. In addition, statistically significant difference was not found between the total scores of both normal and gifted students in the gender-related mobile learning readiness level scale. On the other hand, there was no statistically significant difference between the total scores of the girls and boys on the mobile learning readiness level scale. When the correlation of the sub-dimensions in the mobile learning readiness scale with each other was examined, it was seen that all sub-dimensions were positive and significant.

Keywords: Mobile technology; Mobile learning; Gifted individual

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INTRODUCTION

With the rapidly developing technology day by day, it is called today's technology age. The differentiation of technological devices and their use with wireless internet connections affect life in many ways. Individuals can freely access information with their mobile devices. With this feature brought by technology, learning environments have also been differentiated. Individuals gain knowledge in different learning environments with wireless access. This knowledge acquisition is valid not only for individuals who attend school but also for all individuals who want to acquire knowledge. These opportunities can enable lifelong learning (Sharples et al., 2009). In this way, the concept of mobile learning has emerged with the development of mobile technologies and their use in learning environments.

Literature Review

Mobile Technology and Mobile Learning

Towards the end of the 20th century, it is seen that the world population increased rapidly and there were technological developments as well. With the development of technology, in addition to classical education-teaching activities, technological devices have been used in the education-teaching process. While the use of technology in educational activities was first with radio and television, computer, internet, tablet, and mobile technologies were used with the rapid development of technology. Information technologies, especially mobile technologies (smartphones, mobile phones, personal media tools, tablet computers, etc.) have influenced the majority of people (Sharples et al., 2009; Saran, 2016). One of the most important reasons for its large size is that mobile technologies allow easy access to information at any time and place. Recently, there has been a greater tendency toward mobile technologies, with the increase in power and memory capacity in mobile technologies, and the possibilities such as Bluetooth and wireless internet (Ergüney, 2017). This orientation has started to be used in a wide range in education life as well as in daily life. The concept of mobile learning has emerged with the use of mobile technologies in education (Kalankara, 2021).

In the literature, mobile learning definitions differ according to the characteristics of mobile technologies. Some researchers define mobile learning as the use of portable devices such as tablets, smartphones, and computers in the education process (Cabot et al., 2015; Semertzidis, 2013). Some researchers define the concept of mobile learning as the ability of individuals to use mobile technologies for learning purposes whenever and wherever they want (Sabah, 2016; Bozkurt, 2015; Mahat et al., 2012). So through mobile learning, individuals can access the documents they need instantly, provide access to libraries, participate in distance education courses live or from the recording, access assessments, and games, participate in virtual learning environments, and publish their studies (Hashemi et al., 2011). Also, individuals can interact with each other through mobile learning and share with various tools such as e-mail and social media. Considering the explanations, it is seen that mobile learning offers a flexible learning environment to the individual.

There are many advantages to the active use of mobile learning in the education process. These;

- Formation of place and time-independent learning opportunities with mobile learning, (Sabah, 2016; Bozkurt, 2015; Mahat et al., 2012)
- The portability of mobile devices (Shudong & Higgins, 2005; Hashemi et al., 2011),
- To bring together students who are far from each other and to realize cooperative learning (Corbeil & Valdes, 2007; Hashemi et al., 2011; Sha et al., 2012),
- Students have the opportunity to learn interactively both among themselves and with their instructors (Corbeil & Valdes, 2007; Cavus & Uzunboylu, 2009; Hashemi et al., 2011),
- Flexible application of learning at the most appropriate time and place thanks to the reuse of educational resources (Vogel et al., 2007),
- The responsibility of learning is on the individual (Stone, 2012), and the individual realizes learning according to his/her learning speed (Missildine et al., 2013),
- Increasing motivation for learning in learners due to the portable features of mobile devices (Hashemi et al., 2011),
- Learners can instantly share their observations, studies, and experiences, each as a researcher (Corbeil & Valdes, 2007),
- It helps mobile learning to support lifelong learning in individuals.
- Mobile learning helps individuals support lifelong learning.

Considering that mobile devices have mobile learning features as well as being portable everywhere and can be used at any time and place, the use of mobile technologies in the teaching process is considered important for today. Briefly, the advantages of mobile learning and the use of technologies in the education process is an inevitable situation for today.

Gifted Students and Mobile Learning

Gifted students, according to the report of Marland (1972); “general mental ability”, “ability in a specific academic field”, “creative and productive thinking ability”, leadership ability”, “abilities in the arts”, and “abilities in the psychomotor area” they outperform their peers in at least one of their fields (Sak, 2008). Ministry of National Education (MoNE); Gifted students individuals are defined as individuals who learn faster than their peers, can understand abstract ideas, perform higher than their peers in creativity, leadership, art, and special interests, and have special academic abilities (MoNE, 2016). The developmental characteristics of gifted students are examined in mental, physical, social, and personality dimensions (Leana, 2005). Considering these characteristics, it is seen that there are many differences in the definitions made for gifted students, where gifted students are not a homogeneous group. Considering the general characteristics of gifted students, it can be said that they are creative individuals, original, love to learn, take initiative, and try to complete their work in the best way (Kontostavlou & Drigas, 2019).

Gifted students have different affective, cognitive, and psychomotor skills than their peers, and they perform at a high level in different skill areas from a generation that can use technology well. Information and communication technologies (ICT) have an important role in the effective use of technology. Gifted students' ICT usage purposes; information acquisition and research, communication and interaction, elimination of obstacles and inadequacies, distance education/electronic mentoring, projects and cooperation, virtual trips, multimedia production, and sharing, and providing teaching materials (Öngöz & Sözel, 2018). Gifted students are also aware of how important technology is for their own education (Mann, 1994) and they believe that they will be much more successful in the future if they improve their ICT skills (Kurnaz et al., 2014).

Among the tools used in ICT, there are many tools such as computers, telephones, television, and mobile communication tools. There are features that will provide convenience to students such as the use of mobile communication technologies, rapid access to data, access to the desired video, picture, and sound recordings, and wireless access to the internet (Özel, 2016).

Mobile technologies can be used for faster and easier access to data. Today, the effective use of mobile technologies, which are found in almost every individual, is useful for accessing information easily, analyzing information, and communicating with others. Considering these features, students can benefit from mobile technologies for self-improvement and lifelong learning.

Lifelong learning is important in the education of gifted students. It is important to enable gifted students to access and organize information themselves in lifelong learning processes (Tang & Neber, 2008). Risemberg and Zimmerman (1992) defined gifted students as often curious individuals in their learning processes. Accessing information from various sources with the use of mobile technologies provides more detailed and rapid access to information for all individuals. In this case, considering the characteristics of gifted students, mobile learning allows broad and unlimited access to information that will respond to individual interests, curiosity, and needs. In addition, mobile learning can support personalized learning, which accepts the differences and can support individualized and individual learners (Traxler, 2007).

Purpose of the Research

The main purpose of this study is to examine the mobile learning readiness levels of gifted and normally developing secondary school students. For this purpose, the following research questions were tested.

1- What is the average score of gifted and normally developing students from the scale to determine their readiness for mobile learning?
2- Is there a statistically significant difference between the mobile learning readiness levels of gifted secondary school students and the mobile learning readiness levels of their normally developing peers?
3- Is there a statistically significant difference in mobile learning readiness levels of gifted secondary school students and their peers with normal development according to the gender variable?
4- Is there a relationship between the sub-dimensions of the mobile learning readiness scale of all students participating in the research?

Importance of Research

With the rapid use of mobile technology in daily life, the use of mobile technology has begun to be used by young children (Çakmak & Yalçın, 2013). Especially in the last few years, the diseases that have occurred in the process of staying at home have led to an increase in mobile use. Due to the Covid-19 epidemic, distance education has been started in primary, secondary, and higher education in our country. It is thought that with the active use of mobile tools in the education process, mobile learning has become important for all levels. In this context, the current research has considered that it may be important to determine the mobile learning readiness levels of secondary school students with special abilities and secondary school students with normal development.

Cheon et al (2012) state that the adoption of mobile learning by teachers and students is critically important. It is important in the mobile learning process that students have a high level of mobile learning readiness. Cheon et al. (2012) with Christensen & Knezek (2018) emphasize that readiness for mobile learning is important and that students' mobile learning readiness should be determined before mobile learning applications. Mobile learning readiness can be expressed as students' readiness and preference to use mobile devices as part of the learning process (Mahat et al., 2012).

METHOD

In this study, the correlational survey model, which is a subtype of the general survey model, which is one of the quantitative research methods, was used. General screening models are screening arrangements made on the whole population or a group, sample or sample to be taken from the universe to make a general judgment about the universe in a universe consisting of many elements. Single or relational scans can be made with general screening models. A relational screening model is a research model that does not determine the existence or degree of co-variation between two or more variables (Karasar, 2016). This study aimed to examine the mobile learning readiness levels between gifted students and students with normal development.

Sample Population and Sampling Technique

The study group of the research consists of a total of 346 students who continue their education in the 2021-2022 academic year. Gifted students consist of 176 students who continue their education in Science and Art Centers (BİLSEM) located in Adana city center. Normally developing students consist of a total of 170 students continuing their education in Istanbul.

Measurement

Mobile learning readiness scale developed by Lin et al., (2016), mobile learning self-efficacy (Article 7) optimism (7 items), and self-managed learning (Article 5) three sub-dimensions. The scale, adapted into Turkish by Şata, Torbacı, and Koyuncu (2019), is a 19-item 7-point Likert-type scale. The range of scores that can be obtained from this scale varies between 19 and 133. Those who score high on the scale indicate higher mobile learning readiness, while those with low scores indicate less mobile learning readiness. When the internal consistency characteristics of the mobile learning readiness measurement tool are examined (Şata et al., 2019), found that the Cronbach alpha coefficient for the whole scale was 0.870. Şata et al. (2019) found the Cronbach alpha coefficients for mobile learning self-efficacy, optimism, and self-directed learning sub-dimensions as 0.889, 0.866 and 0.860, respectively. According to our results, the Cronbach alpha coefficient of the mobile learning readiness measurement tool was found to be

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0.922. The Cronbach alpha coefficient for the sub-dimensions was found to be 0.874, 0.899 and 0.834, respectively, for the sub-dimensions of mobile learning self-efficacy, optimism, and self-directed learning.

Data Analysis

As a result of the Kolmogorov-Smirnov test in mobile learning readiness scale to test normality; since it is .08 ($p>.05$) for gifted students and .07 ($p>.05$) for the whole study group, it can be said that the data are normally distributed (George & Mallery, 2010). For this reason, parametric statistical techniques were used in the analysis of the data.

Within the scope of the research, descriptive statistical analyzes were carried out to carry out inferential statistics for the scores obtained by the participants from the scale. The distribution in this direction is as seen in Table 1.

Table 1. Descriptive Statistics Results

Level	Variable	n	*f*	%
Gifted	Gender	Girl	88	50
		Boy	88	50
	Grade Level	5th grade	71	40.3
		6th grade	68	38.6
		7th grade	26	14.8
		8th grade	11	6.3
Normal	Gender	Girl	70	41.35
		Boy	100	58.65
	Grade Level	5th grade	68	40.4
		6th grade	47	27.5
		7th grade	31	18.1
		8th grade	24	14

When Table 1 is examined, it is seen that the majority of the participants are 5th and 6th-grade students. The participants are distributed close to each other according to the gender variable. SPSS 21 statistical analysis package program was used and an independent sample t-test was used to determine whether there is a significant difference by comparing the mobile readiness levels of gifted students and students with normal development. In addition, the effect size (Eta squared) values, which show the degree of influence of the independent variable on the dependent variable, were also calculated. Calculated effect size; If it is between $.01 \leq \eta 2 < .06$, it is interpreted as a low-level effect, between $.06 \leq \eta 2 < .14$ it is interpreted as a medium effect, and between $\eta 2 \geq .14$ it is interpreted as a large effect (Cohen, 1988).

FINDINGS

Table 2. Descriptive Statistics for Mobile Learning Readiness Levels

Measure	N	Max.	Min.	$\bar{X}$	SD
Total	346	133	27	95.36	23.08
Gifted	176	133	47	99.06	20.32
Normal	170	133	27	91.53	25.12

When the information in Table 2 is analyzed; it is seen that the average score of the students from the mobile learning readiness scale is at a high level ($\bar{X}$ = 95.36). When the average of the student's readiness for mobile learning is examined, it is seen that the average of the gifted students is the highest ($\bar{X}$ = 99.06).

Table 3. Independent Samples T-Test Results Comparing Mobile Learning Readiness Levels of Specially Talented and Normally Developing Secondary School Students

				t-test		
	Students	**N**	**$\bar{X}$**	**SD**	***t***	***p***
Mobile Learning Readiness	Gifted	176	5.21			
	Normal	170	4.81	.007	3.071	.002

As seen in Table 3, mobile learning readiness mean scores of gifted students ($\bar{X}$ = 5.21) are statistically significantly higher (t=3.529, p<.05) than average scores of students with normal development ($\bar{X}$ = 4.81).

According to the criteria proposed by Cohen (1988), the effect size is interpreted as 0.2 small, 0.5 medium and 0.8 large effect size. The value calculated as the effect size was 0.5 and it was determined that the effect size was medium. This finding shows that the mobile learning readiness levels of the gifted students are higher than the students with normal development.

Table 4. The Results of the Independent Group T-Test Comparing the Mobile Learning Readiness Levels of Middle School Students with Special Abilities and Showing Normal Development According to the Gender Variable

				t-test		
	Groups	**N**	**$\bar{X}$**	**SD**	***t***	***p***
Mobile Learning Readiness	Girl	159	4.96			
	Boy	187	4.07	.179	-.899	.369
	Gifted Girls	88	5.20	.493	-.122	.493
	Gifted Boys	88	5.22			
	Normal Girls	71	4.65	.004	-1.43	.156
	Normal Boys	99	4.94			

As seen in Table 4, when the mobile learning readiness levels of all students were analyzed according to the gender variable, no statistically significant difference was found (t=-.122, p>.05). Likewise, when the mobile learning readiness levels of gifted students were examined according to the gender variable, no statistically significant difference was found (t=-.899, p>.05). Finally, when the mobile learning readiness levels of the students with normal development were examined according to the gender variable, no statistically significant difference was found (t=-1.43, p>.05). The value calculated as the effect size is .002 and it can be stated that the effect size is at a low level (Cohen, 1988). This finding shows that there is no significant difference in mobile learning readiness between genders.

Table 5. Correlation Analysis Results to Determine the Relationship Between the Sub-Dimensions of the Mobile Learning Readiness Scale of Specially Talented and Normally Developing Secondary School Students

N=346	General	1	2	3
Genel	1			
1 Mobile Learning Self-Efficacy	.868**	1		
2. Optimism	.838**	.559**	1	
3. Self-Directed Learning	.728**	.522**	.404**	1

According to the result of the Pearson Correlation Analysis performed in Table 5, a significant and positive relationship was found between Mobile Learning Self-Efficacy and Optimism, r = .559, *p*<.001. It has been found that there is a significant and weak positive relationship between Mobile Learning Dec-Efficacy and Self-Directed Learning, r = .522, *p*<.001. It has been found that there is a significant and positive relationship between Optimism and Self-Directed Learning, r = .404, *p*<.001.

RESULTS AND DİSCUSSİON

This study aimed to examine and compare the mobile learning readiness levels of gifted and normally developing students in terms of total scale items and gender variables. In addition, the scale has three dimensions and the relationships between these dimensions, mobile learning self-efficacy, optimism, and self-directed learning were examined. Normally developing students consist of a total of 170 students continuing their education in Istanbul. A total of 346 students participated in the research.

As a result of the analysis, it was determined that the average score of all students on the mobile learning readiness scale was high. Supporting the results of the study; Mahat et al. (2012) and Arslan (2019) concluded in their studies that university students' mobile learning readiness levels are high. However, when the average score of the students for mobile learning readiness is examined, it is seen that the average score of the gifted students is higher. The mobile learning readiness levels of gifted students differed significantly from the students with normal development. It is thought that mobile learning readiness levels may be high in students since mobile device use starts in early childhood (Çakmak & Yalçın, 2013).

It was determined that there was no difference according to gender in the mobile learning readiness scale of secondary school students with special abilities and normal development. There are studies that support this finding of the study. In the studies conducted by Kurnaz (2010) and Kıcı (2010), no significant difference was observed in terms of gender variables. In the study of Kuşkonmaz (2011) to determine the level of perception of mobile learning, no significant difference was found between male and female teachers. In a study conducted by Kantaroğlu and Akbıyık (2017), students' attitudes towards mobile learning were determined and no significant difference was found in the research according to the gender variable of the students.

Today, mobile devices are used effectively in many areas of life. Every day we live more and more intertwined with technology. Especially with the use of mobile technologies in education, mobile learning has an important place in our lives (Kıcı, 2010). In this direction, mobile learning environments should be introduced to individuals both for educational environments and for lifelong learning. Educational programs to be prepared in the education and training process need to be developed and constantly updated by technological learning environments. In the studies conducted, it has been found that students use mobile learning efficiently to improve their knowledge (Mao, 2014). Almuttairi (2020), on the other hand, in his study with gifted female students, found that gifted female students who benefited from mobile learning achieved effective results from mobile learning. An experimental study was conducted and students were provided with the free iTunes U application. In the iTunes U application, besides different educational content, there are videos, pictures, pdf, and presentations. As a result of mobile learning performed with iTunes U, it was found that the results of the questionnaire applied to the students had a significant effect on their metacognitive thinking level of the students.

Especially in training aimed at continuous training or gaining skills with mobile learning, appropriate evaluations should be made for the purpose. As a result of these evaluations, a qualification certificate or certificate related to the field should be issued.

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Conflict of Interest Disclosure

The author declares no conflict of interest.

Consent for Publication

The authors do consent for publication of this work.

Ethical Rules

The following ethical steps were followed in this research. Since the research was carried out during the pandemic process, the questionnaires were taken over the google form and filled in by the students who requested it, with the permission of the students and their families.

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The Impact of Engineering Design-based Activities on Eighth-Grade Students' Environmental Awareness and Entrepreneurial Perceptions and Skills

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ABSTRACT

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This study examined the impact of engineering design-based, thematic activities on 8th-grade students' environmental awareness and entrepreneurial perceptions and skills. The engineering activities were designed to introduce topics and issues that are tied to energy conversion and environmental science. Thirty-seven students (21 girls, 16 boys) completed the activities and participated in the one-group pretest-posttest quasi-experimental study. The data were gathered using the Environmental Awareness Scale (EAS), Entrepreneurial Perception Scale (EPS), and student worksheets and artifacts. Entrepreneurial skills were assessed using the Entrepreneurial Skills Checklist (ESC). Descriptive statistics and paired-samples T-test were conducted for data analyses. Results showed a significant difference between students' pre-test and post-test scores of the EAS and EPS which indicated that the engineering design-based activities greatly impacted the eighth-grade students' environmental awareness and entrepreneurship perceptions. These activities also contributed to the development of students' entrepreneurship skills such creativity, critical thinking, self-confidence, social skills and group work, leadership, decision-making, and risk-taking. This study offers insight into engineering design-based activities and promotes the development of students' environmental awareness and entrepreneurial perceptions and skills in the middle school science classroom.

Keywords: Science education; Engineering design process; Entrepreneurship; Environmental awareness

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INTRODUCTION

Today, the need for individuals who approach problems from different perspectives, produce innovative solutions, and have 21st-century skills is steadily increasing. The 21st-century skills such as entrepreneurship, the ability to use creative problem solving approaches, take risks, and evaluate and communicate information is critical for success in the global economy (Drucker, 2014). The term "entrepreneur" was first introduced in the early 18th centuries in French economics. An entrepreneurial individual has been defined as a person who promotes economic growth by innovating and creating new products and services (Akçin, 2021). European Commission Working Group on Entrepreneurship Education defines entrepreneurship as "a key competence for all learners, supporting personal development, active citizenship, social inclusion and employability" (European Commission, 2015a, p.8). According to The Turkish Qualifications Framework (TQF), a "sense of initiative and entrepreneurship" refers to an individual's ability to turn ideas into action. Entrepreneurship is often associated with creativity, innovation and risk-taking, and the ability to plan and manage projects to achieve objectives (Vocational Qualifications Authority [VQA], 2015, p.24). In addition, entrepreneurship is characterized as developing commercial products and gathering production-related factors to solve problems and needs (Ürper, 2015) and is mainly associated with the economy and industry. In this era, it is essential to help students build entrepreneurship skills and develop entrepreneurial mindset. To do that, efforts should be made to provide entrepreneurship-focused education that encourages entrepreneurship, creativity, innovation, problem solving, and collaboration (Yurtseven & Ergün, 2018).

With the emphasis placed on entrepreneurship education in the K-12 education system in Turkey, students are now provided opportunities to develop entrepreneurship skills starting from kindergarten. These critical skills include seeing problems as opportunities, gathering resources and key information to develop solutions to problems, developing and implementing projects, innovating, and managing and organizing strategies. Commercial entrepreneurship becomes the main focus of entrepreneurship learning experiences at the secondary school level. Entrepreneurship education is integrated in the national science curricula which provides guidelines and instructional materials for the teachers (Ministry of National Education [MoNE], 2009). For example, one of the main objectives of the middle school science curriculum is to develop students' career awareness and entrepreneurship skills related to science. The curriculum includes core science concepts and practices of science, engineering, and entrepreneurship. Within the program's scope, students are primarily expected to define daily needs or problems related to the identified core science concepts. The national curriculum suggests that solving problems improve tools, objects, or systems being used. In addition, the process involves material, time and cost management. Students brainstorm solutions, compare alternative solutions, and choose the appropriate one within the scope of criteria and constraints. They are also expected to communicate design solutions. This whole design and production process is carried out in the school environment. It is important to note that, students are required to conduct experiments during the product development phase, analyze data, and use scientific data in the design process. This integrated approach aims to improve students' entrepreneurship skills with engineering design-based science activities in the curriculum. To help building entrepreneurial skills, students are expected to create strategies and use promotional tools for marketing the product they have designed in an engineering design-based task. For example, "students are recommended to make public service announcements or short films to promote their products" (MoNE, 2018, p.10).

As discussed in the Turkish national science curriculum, integrated STEM (Science, Technology, Engineering, and Mathematics) activities provide a rich learning environment to develop students' entrepreneurship skills (Ezeudu et al., 2013; Uçar, 2020). Previous research also demonstrates that interdisciplinary learning environments should be created to enable students from a young age to gain entrepreneurial experiences in and out of school (Karakılçık & Uçar, 2022; Nambisan, 2014; Rina et al., 2019). Integrated STEM education is an essential interdisciplinary approach for students to acquire entrepreneurship skills such as creativity, innovation, critical thinking, and risk-taking. The STEM education reform movements worldwide emphasize the importance of interdisciplinary learning experiences and the development of interdisciplinary knowledge and skills in K-12 (Herdem & Ünal, 2018; Sahin et al., 2014). One of the primary purposes of STEM education is to educate creative, innovative, competitive entrepreneurs and problem-solvers who can apply knowledge and skills from different disciplines to problems (Sanders, 2009). There are many approaches to STEM education. Bryan and Guzey (2020) noted that "the ubiquitous use of the term STEM, with little definitional consistency, runs the risk of diluting its potential value for enhancing, reforming, and informing K-12 research, policies, programs, and practices" (p. 6). The authors use the term to refer to an instructional approach that uses engineering design as a vehicle for teaching and learning science. Engineering is a natural connector to integrating STEM disciplines since design solutions require applying knowledge and skills from science and mathematics. The engineering design process is "(1) highly iterative; (2) open to the idea that a problem may have many possible solutions; (3) a meaningful context for learning scientific, mathematical, and technological concepts; and (4) a stimulus to systems thinking, modeling, and analysis (National Academy of Engineering & NRC, 2009). Recent K-12 education reforms emphasize the necessity for students to understand engineering and practices. For example, the European Commission report on science education authors states that K-12 education should emphasize engineering design and highlight emerging technologies in engineering education to help students pursue careers in STEM (European Commission, 2015b). It is essential for K-12 students to engage in various STEM education activities focusing on engineering concepts and practices for development of entrepreneurial skills (European Commission, 2018).

The STEM activities should be realistic, authentic, and relevant to students' lives. The interdisciplinary nature of environmental problems (air and water pollution, climate change, etc.) we encounter daily require utilizing STEM knowledge and entrepreneurship skills to solve them (Nambisan, 2014). Environmental education helps students make informed decisions and engage in problem-solving processes to solve ecological issues (Erten et al., 2003). The general purpose of environmental education is to raise environmentally conscious and sensitive individuals to teach students about the effective and efficient use of natural resources, determination of ecological limits, prevention of depletion and pollution, and promote environmental awareness (Güven, 2011). Being environmentally aware means understanding the consequences of our behavior and choices to the environment, making environmentally-conscious decisions, and committing to making changes to protect the environment. Many environmental problems are constantly occurring in today's world, and there is a critical need for increasing environmental awareness. This can be achieved by providing students opportunities to engage in engineering design activities that require them to develop solutions to environmental problems. To this end, we developed a series of engineering design-based, thematic science activities that focus on energy conversion and environmental science. These activities were used to give secondary school students the responsibility develop solutions for design challenges and, in turn, develop their entrepreneurship skills (Deveci & Çepni, 2014; Middleton et al., 2014). The current study aimed to address the following research question:

- What is the impact of the engineering design-based activities on students' environmental awareness, entrepreneurial perception, and entrepreneurial skills ?

METHOD

The one-group pretest-posttest quasi-experimental design was used in this study. The one-group experimental design allows researchers to establish causal relations between problems identified in the research (Shaughnessy et al., 2006).

Participants

The convenience sampling method was used to determine the study participants. The research sample comprised of thirty-seven 8th-grade students (21 girls, 16 boys) from a public school in Turkey.

Data Collection Tools

The data were gathered using the Environmental Awareness Scale (EAS), Entrepreneurial Perception Scale (EPS), and students' worksheets and artifacts.

Environmental Awareness Scale (EAS)

EAS was used to assess the impact of engineering-based activities on the environmental awareness of the eighth-grade students before and after they engaged in the activities. It was developed by Güven (2011), considering the cognitive steps of Bloom's Taxonomy, and consisted of 44 items on a Likert-type scale (3=Yes; 2=No idea; 1=No). The scale includes sub-factors in the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. The EAS's reliability was established through Cronbach's Alpha, which was found to be .79. Therefore, the scale is considered to have high internal consistency.

Entrepreneurial Perception Scale (EPS)

EPS was utilized to assess the engineering activities' impact on the students' entrepreneurship perception levels before and after the activities. It was developed by Özcan (2019) and consisted of 28 items. There are five sub-dimensions in the scale: perception of innovation and creativity, self-confidence, leadership and taking initiatives, social skills and group work, and risk-taking tendency. The scale has a high Cronbach's Alpha, calculated as .85.

Entrepreneurship Skills Checklist (ESC)

ESC was used to measure the impact of the activities on the students' entrepreneurship levels. It is a checklist developed by Çetin (2015) and includes 26 items with six sub-dimensions: creativity, innovation, risk-taking, critical thinking, need to succeed, and interpersonal relations. The checklist was scaled as "weak, average, good, very good." The highest score on the checklist is 104, and the lowest score is 26.

Students' artifacts

Artifacts were collected through worksheets and engineering design-based product presentations. Worksheets were developed according to the engineering design cycle (Hynes et al., 2011). Three experts in STEM and engineering education reviewed the worksheets. Necessary changes were made to the worksheets based on the feedback provided by the experts in the field. During the activities, the students answered the questions on the worksheets as a group. However, they brainstormed ideas and solutions to the design problems individually first and then as a group. Groups presented their products to their peers. Presentations focused on production planning, marketing, sales, and after-sales services. Design presentations and worksheets were collected and analyzed.

Procedures

Students engaged in three engineering design-based activities focused on energy conservation and environmental science themes. Activities were carried out during an elective course named Environmental Education (six hours a week). Table 1 summarizes the five-week-long study timeline.

Table 1. Overview of the Research

Week	Content
1	Implementation of the pre-test (EAS & EPS) Introduction to engineering: What is engineering? What are the steps of the engineering design process?
2	Sun-loving school design activity
3	Botanic garden science field trip Eco-friendly vehicle design activity
4	Water filter design activity
5	Implementation of the post-test (EAS & EPS)

Each design activity was completed in six 40-minute class periods, and students used the engineering design process (Hynes et al., 2011) to solve the given design challenges. In the "Sun-loving school activity," students were asked to design a sustainable, green school that saves energy and environmental resources. The design criteria fell into several groups in this activity, including energy conversion, cost, time, and aesthetics. In this activity, students collected and analyzed temperature changes that can be used to evaluate the effectiveness of their designs.

Figure 1. Students make their design as a team

In the “Eco-friendly vehicle design” activity, students evaluated the air quality measurement of the city that they lived in. They then discussed the following questions to help them recognize the problem: “In your city, between 2017 and 2022, what is the air-pollution parameter that increased the highest?”, “How do air-pollution parameters change in the daytime and at night?”, “What might be the factors affecting this change?”, “What factors do you think cause air pollution?”, “What can be done to reduce the air pollution resulting from transportation?” Next, the students were asked to design a vehicle by analyzing the structures and movements of living creatures in the nature. The number of DC engines used in the designed vehicle, the distance covered by the vehicle in the determined time, the energy conversion in the vehicle, the vehicle's cost, its aesthetics, and time to complete the design task were set as the design criteria for the activity. Students visited a local botanical garden to observe and collect data to identify a living organism to mimic their eco-friendly vehicle’s features.

In the “Water filter design activity,” a graph showed the per capita wastewater generation rates in the City was shared with the students to identify the year with the highest proportional increase in the amount of wastewater and discuss the reasons for the rise, and possible solutions to reduce wastewater formation. Then, the importance of water for living creatures, factors that cause water pollution, and the depletion of water resources were discussed. Students were then asked to design a portable water filter for wastewater reuse. Following the engineering design process, the students built their designs using zeolite, activated carbon, natural sand, pebbles, tree leaves, coal, fabric, bottles, and cotton. At the end of the activity, the Total Dissolved Solids (TDS), pH and conductivity values were measured three times before and after the water was filtered and averaged. The amount of water purified per minute from the designed filter was compared with the initial average values by taking note of the TDS, pH, and conductivity values of the treated water.

In all three engineering activities, entrepreneurship-related dimensions have been added to the engineering design steps (Deveci, 2018), especially highlighting the social and cultural dimensions of entrepreneurship, apart from its financial dimension. Until problem identification and product testing, attention was drawn to the cost, estimated sales amount, innovative aspects of the product, and the possible risks. During the design product presentation, each group was asked to produce a catchy slogan. The groups were acting as entrepreneurs and they were asked to present their designs to their classmates, explaining "production planning, marketing, sales, and after-sales services." Thus, students research how environmental and economic issues are affected by science and technology and manage the time, cost, and accessibility constraints.

Data analysis

The descriptive statistics and paired-samples T-test were used for data analysis since the data obtained from the EAS and the EPS were found to have a normal distribution. The eta-squared (η^2) coefficient was calculated to determine the effect size. The first author and an independent observer weekly analyzed students worksheets, design products, and the presentation of the products utilizing the ESC. Each used the entrepreneurship skills checklist independently. Next, the averages of scores for each activity were calculated, and each sub-dimensions change on the checklist was examined. Cohen's Kappa was adopted to determine the reliability of the agreement between scores given to checklists by the first author and the observer, which was calculated to be .82.

RESULTS

Environmental awareness

A paired-samples t-test was conducted to evaluate the impact of the engineering design-based thematic activities on students' scores on the EAS. As shown in Table 2, there was a statistically significant difference between pre-test [M=100.324, SD=7.337] and post-test results [M=124.729, SD=3.404, t (36) =27.424, p<.0005]. The eta squared (η2= .95) indicated a high effect size.

Table 2. A Paired-samples T-test Results on EAS' Pre-test and Post-test Scores

	N	*M*	*SD*	*t*	*df*	*p*	η^2
Pre-test	37	100.324	7.337	27.424	36	.000	.95
Post-test	37	124.729	3.404				

Entrepreneurship perception levels

A paired-samples t-test was conducted to evaluate the impact of the engineering design-based thematic activities on students' scores on the EPS. As shown in Table 3, there was a statistically significant difference between pre-test [M=93.567, SD=14.814] and post-test results [M=114.675, SD=10.181, t (36) =6.626, *p*<.0005]. The eta squared (η2: .73) indicated a high effect size.

Table 3. A Paired-samples T-test Results on EPS' Pre-test and Post-test Scores

	N	*M*	*SD*	*t*	*df*	*p*	η^2
Pre-test	37	93.567	14.814	6.626	36	.000	.73
Post-test	37	114.675	10.181				

Entrepreneurial skills

ESC was used to evaluate the changes in students' entrepreneurship skills during engineering design-based activities. As shown in Figure 2, the groups' average scores increased from the first to the last design activity. The lowest average score in the Sun-loving school activity was observed in innovation and interpersonal relations. In the first activity, the students received the highest score in the creativity dimension. For the eco-friendly vehicle activity, the highest score increase was observed in the risk-taking dimension. As for the water filter activity, students' risk-taking and critical thinking skills greatly improved. The lowest improvement occurred in the creativity sub-dimension.

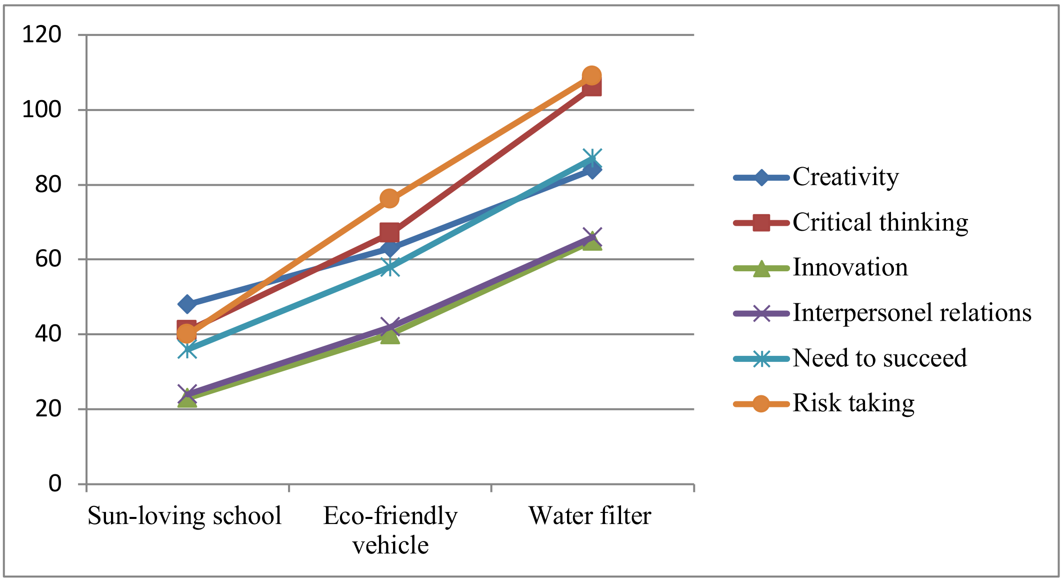

Figure 2. Average of students' entrepreneurship skills score

DISCUSSION AND CONCLUSION

This study examined the impact of engineering design-based activities on 8th-grade students' environmental awareness, entrepreneurial perceptions, and skills. The activities were designed around a specific theme, energy conversion, and environmental science. Results showed a significant difference between the pretest-posttest average scores for environmental awareness. Engineering design-based activities that focus on environmental science activities positively impacted the students’ environmental awareness. The results of this study support previous findings that points out the benefits of design-based activities on students’ environmental awareness. Gottfried (2015) found that STEM education activities increased students' environmental awareness, attitudes, and motivations. Çalışıcı (2018) also reported that STEM activities performed with eighth-grade students within the Living Creatures and Energy Relations unit positively affected students' environmental awareness and attitudes.

The current study also showed that engineering design-based activities positively impacted the students’ entrepreneurial perceptions. This finding also supports prior studies reporting that engineering design-based activities positively impacted the students’ entrepreneurial perceptions (Shahin et al., 2020). Similarly, Turgutalp (2021) found that activities based on the STEM 5E model improved middle school students' entrepreneurial skills and increased their academic success. The explored increase in entrepreneurial perceptions is regarded as an improvement caused by the students’ participation in the entrepreneurship-focused STEM activities.

Concerning the entrepreneurial skills, the highest increase was observed in risk-taking skills. The risk-taking skills were greatly improved after the eco-friendly vehicle activity, which was carried out in the botanical garden. Çepni and Deveci (2014) state that out-of-school learning environments encourage students to take risks and help them develop risk-taking skills. Similarly, Uçar (2020) proposed that engaging in risk-taking problems related to environmental issues is important for students to reveal and develop risk-taking skills. In this study, students’ focus on environmental issues they encounter in their daily lives may have contributed to the development of risk-taking skills.

The findings also showed an increase in the descriptive values of the creativity sub-dimension after the activities. According to Aktamış ve Ergin (2006), in science education, creativity is the ability to produce solutions when facing a problem or situation. Konca-Şentürk (2017) found that engineering design activities positively contribute to the development of students’ creative thinking skills. In conclusion, this study found that environmental science-based thematic engineering design-based science activities increased students' environmental awareness and entrepreneurship perceptions and skills.

Limitations and Recommendations for Future Research

This study offers insight into understanding the engineering design-based activities and their influence on the development of students’ environmental awareness and entrepreneurial perceptions and skills in the middle school science classroom. The study has several limitations. First, due to the number of study participants, the researchers didn’t perform any comparison or analysis based on the gender of the participants. Therefore, further studies may be conducted with groups displaying a near-equal distribution of gender. In addition, since students worked in small design groups, the entrepreneurial skills checklist was used for groups. Also, in this study, the examined sub-dimensions for entrepreneurship were creativity, critical thinking, innovation, interpersonal, need to succeed, and risk-taking. In another study, other sub-dimensions of entrepreneurship skills could be addressed. Finally, a future study could use a different learning environment such as an out-of-school learning setting, include students from different grade levels, or focus on different science concepts to further document the benefits of engineering design activities on students' environmental awareness and entrepreneurial perceptions and skills.

Ethical Rules: In this research, the ethics committee approval notification document containing the eligibility decision for the research was received from the Aksaray University Human Research Ethic Committee (Date: 19.09.2019, No: 2019/08-12). All ethical procedures were followed during and after completing the study.

Authors Contributions: This study was written on the basis of the first author's master's thesis titled "The effect of engineering design activities on the environmental awareness, entrepreneurship perception and skills of 8th grade students" which was completed on January 21, 2021. The subject of the study was suggested by the second and third authors. The first author developed engineering design-based activities. The second and third authors examined the activities. Evaluation of the findings, discussion, conclusion, and development of suggestions were performed by the first author and supervised by the second author. Third author also contributed to literature review and discussion parts of this study.

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Learning With STEM is Not Difficult at All!

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ABSTRACT

Research Article

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The aim of this study is to teach how to design a circuit using simple electrical circuit elements with a STEM activity conducted with 4 students with learning difficulties studying at a primary school located in the southern region of Anatolia. The study was carried out in the form of extracurricular activities focused on science lessons on the subject of simple electrical circuits for 8 class hours over a period of 2 weeks. After the quantitative stage of the study, which was designed as a mixed method design, the qualitative stage was conducted in the study, a STEM process rubric was used as the quantitative data collection tool, while an observation form and interview form were used as the qualitative data collection tools. At the end of the study, it was determined through interviews that the STEM activities made a significant academic contribution to the participants, that they had a lot of fun while learning, and that they did not easily forget what they had learned. The participants, who stated that the activities benefited them academically in science and mathematics, also reported that they used the knowledge about science and mathematics they gained here in other subjects as well.
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Keywords: STEM, learning disability, science education, primary school

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INTRODUCTION

In the world of the 21st century, in which rapid changes are being experienced through the effect of globalisation, countries are in constant competition in the fields of production, design, invention and technology. This competition has encouraged countries to science, engineering and technology (Kaplan, 2019). For this reason, countries have abandoned educational approaches that employ the content transfer of information and have begun to adopt teaching approaches that produce, design and are based on creativity. In the teaching approach towards the fields of science, engineering, design and production, STEM comes to the fore. STEM is a teaching approach that is based on the integration of disciplines and adopts the model of learning by doing and experiencing. Bybee and Dugger (2010) defined STEM as a new educational approach that encompasses the disciplines of Science, Technology, Engineering and Mathematics in unity, increases learners' motivation to do research by developing their sense of curiosity, and develops their problem solving and creative thinking skills. The STEM educational approach is defined as the integration of the learning objective of one STEM discipline focused on by associating it with the objectives of the other STEM disciplines (Çorlu, et al., 2014). It has been reported in many studies that the STEM approach, which is design-based and includes learning by doing and experiencing, is effective in both enabling meaningful learning and in developing problem solving skills in education (Bryan, et al., 2016; Author, 2018; Corlu & Aydın, 2016; Ergün & Balçın, 2019; Gwon- Suk & Sun Young, 2012; McClain, 2015; Wosu, 2013). Furthermore, although STEM education is effective at all grade levels of education, its effect has been determined to be greater at primary school level (Becker & Park, 2011; Murphy & Mancini-Manuelson, 2012; Lamb, et al., 2015).

STEM and individuals with special needs (ISNs)

It has been determined that in the world population, the number of students who are at a lower educational level than their peers due to premature births, genetic factors, consanguineous marriages and accidents is increasing day by day (Batu & Kırcaali-İftar, 2006). In the Decree Law No. 573 on Special

Education of the Ministry of National Education (MoNE), these students are defined as: "Individuals with Special Needs (ISNs) who, for various reasons, differ significantly from the level expected from their peers in terms of educational qualifications" (MoNE, 1997) Ensuring that ISNs are not separated from social life and benefit from education and training activities according to the principle of the least restrictive environment is achieved through inclusion-integration education. However, while ISNs' social interaction skills with their peers increase thanks to inclusive education, problem solving skills are pushed into the background because appropriate learning methods for their level are not applied.

Theoretical Framework

In terms of equality of opportunity in education, it is very important that ISNs are trained like their peers by fostering 21st century skills with teaching approaches appropriate for their level in classes. STEM education, which is one of the approaches that foster these skills in individuals, is an important teaching approach in equipping individuals with 21st century skills such as innovation, analytical thinking, problem solving and cooperation (Kennedy & Odell, 2014). Despite such importance, the studies conducted on STEM education for ISNs are limited (Balçın & Yıldırım, 2021; Hwang & Taylor, 2016). However, teaching and learning STEM disciplines are especially valuable for these students in improving their quality of daily life, because STEM is intertwined with daily life situations (e.g., using technology, using electronic devices and programs such as smartphones and iPads, and using chemicals like soap, oil, and paraffin). Although research in STEM disciplines for students with disabilities is still increasing, very few practical guidelines for teachers in inclusive and non-inclusive environments have been proposed and developed in order to increase students' achievement and their accessibility to STEM (Basham & Marino, 2010; Dunn, et al., 2012; Ludlow, 2013). It can be said that ISNs face some obstacles to STEM education careers. One of these are characteristics related to teachers. For example, topics such as teachers' lack of adequate STEM knowledge, and their insufficient educational experience and readiness related to ISNs can be listed (Margot & Kettler, 2019). Other than these, the remaining obstacles can be listed as the lack of adequate infrastructure and educational opportunities for STEM education in schools, the lack of an integrated curriculum, as well as the lack of understanding of these barriers and their effects on employment. Common obstacles to accessing STEM education for all ISNs include (a) a lack of STEM role models (Hasse, 2011; Lee, 2011); (b) parents' and teachers' misconceptions that students with disabilities will not be successful in STEM, resulting in a lack of encouragement for them to take courses in these areas (National Science Foundation, 2002); (c) a lack of appropriate information and counselling (Alston, et al., 2002); (d) teachers' inadequate knowledge and skills on how to involve students with disabilities (Rule, et al., 2009); (e) technical barriers to science education (e.g., inaccessible laboratories) (Hasse, 2011); and (f) lower participation rates in structured and unstructured STEM-related activities (e.g., mathematics and science) (Eriksson, et al., 2007).

There are many disability groups among the aforementioned inclusion students. One of these is learning disability. In 1983, the United States National Joint Committee on Learning Disabilities (NJCLD) defined learning disability as "a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities".

The areas in which individuals experience learning difficulties may differ from each other. While some individuals have learning difficulties in verbal areas such as understanding and interpreting, other individuals have learning difficulties in subjects that require numerical reasoning, such as the disciplines of mathematics and science. STEM education, in which the disciplines of science and mathematics are integrated, contributes to Special Learning Disability (SLD)s' effective and permanent learning since it offers multiple learning environments by applying the doing-experiencing and active learning methods rather than the traditional educational approach. In their studies, Hwang and Taylor (2016) and Author (2017) stated that conducting STEM education activities for inclusion students with intellectual disabilities will increase their academic achievement in the disciplines of mathematics and science. Moreover, in the study conducted by Balçın and Yıldırım (2021), it was determined that due to STEM activities conducted for inclusion students with mild intellectual disabilities, there was an increase in the percentage of students' knowledge changes regarding the subject of science and in the students' interest in the subject. Bellman, et al. (2015) implemented STEM with inclusion students who had intellectual disabilities, and as a result of this study, it was concluded that STEM education increased the inclusion students' motivation, academic achievement and self-confidence. In the study carried out by Biçer (2019), STEM activities were conducted for inclusion students in support training rooms. In the findings obtained in this study, it was concluded that the STEM approach was effective in teaching science to inclusion students with intellectual disabilities. Yuen, et al. (2014), conducted STEM activities with two students with severe autism spectrum disorder in order to examine the effect of STEM activities on social communication. As a result of the study, it was observed that there was a significant improvement in the ability of the students with autism to communicate with their peers. Moreover, Akarsu, et. al. (2022) reported that the activity they developed for inclusion students with visual impairments was very effective on an electromagnet design in the science lesson for the students.

Based on the results of this study, it is seen that STEM education practices concretise abstract concepts, enable permanent learning with multiple learning environments, and develop individuals' psychomotor-social communication skills. When the relevant literature was scanned, however, it was concluded that the STEM approach has not been adequately implemented with SLDs. In this context, since the STEM approach has not been applied to SLDs, our study will contribute to the literature.

ACTIVITY IMPLEMENTATION

The students participating in the study were students with a diagnosis of learning disability, and the activity conducted with them was carried out during their lesson hours in the students' support training room. The reasons why the support training room hours were chosen were that in terms of the students' learning, the students could learn faster during the times they had one-to-one lessons, feedback could be obtained, and the things they learned were more permanent. Moreover, the activity was not detached from the curriculum and was designed in line with the individualised education plan (IEP). The implementation of the STEM approach within the scope of the IEP was preferred with the foresight that it could further increase the permanence of learning. It is possible that for SLDs, STEM's product-oriented, engineering-based make-up based on doing and experiencing will lead to permanent learning in them. Accordingly, in this study, a STEM activity for SLDs was designed and tested. This activity was prepared for teachers in order to enable the active participation in STEM activities of SLDs who are educated together with their peers (Figure 1).

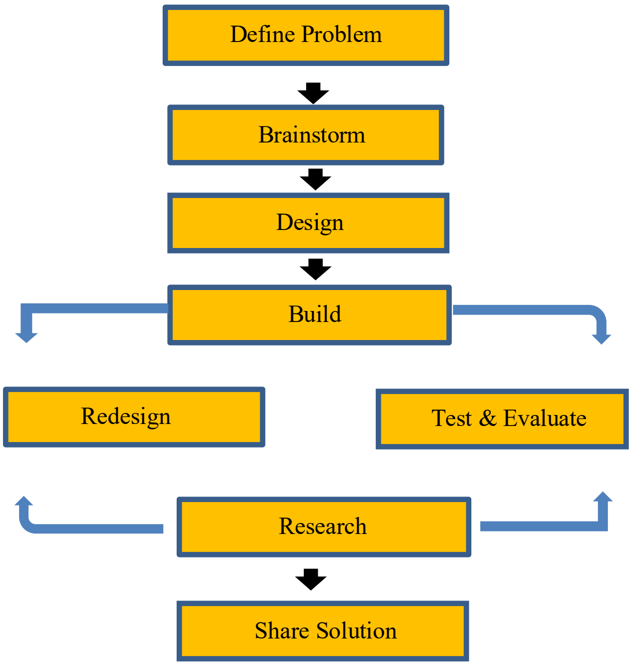

Figure 1. Teachers Exploring STEM Integration (Lesseig, et al., 2017, p.18)

Define Problem: Determining the problem. What kind of problem should be presented in which field with the students?

Brainstorm: What kind of path should be followed to solve the problem? Different solutions are explored with the students.

Design Process: The materials used in the activity to be conducted are specified, and how and where they will be used in the design is determined.

Construction phase: The construction of the design is begun. The accuracy of the design is tested on the students by guiding them (Test & Evaluate). They are also given the opportunity to do research by giving them time to redesign the designs which are wrong (Redesign and Research).

Share Solution: Individuals or groups who carry out their designs correctly share the solutions they find with their friends. At this stage, the teacher is the guide and director.

It will also serve as a guide to how learning objectives should be brought together for activities. The activity meets the education standard requirement for K-12 science education (Table 2).

Table 2. Application of education standards (MoNE , 2018; NGSS, 2022)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts	Turkish MoNE Learning Objectives
4.PS3-2.Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents	PS3.A: Definitions of Energy The faster a given object is moving, the more energy it possesses.	Energy and Matter Energy can be transferred in various ways and between objects.	F.4.7.1.1. The student can recognise the circuit elements that make up a simple electrical circuit with their functions.
3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved	(4-PS3-1) Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)	(4-PS3-1), (4-PS3-2), (4-PS3-3) (4-PS3-4)	F.4.7.1.2. The student can set up a working electrical circuit

This study has been designed around the following research question: What is the impact of a STEM activity designed for SLDs on their learning outcomes?

The studey was carried out over a period of 2 weeks in the form of extracurricular activities focused on science. The STEM activity was conducted under the supervision of the researchers. The activity was evaluated with the STEM process rubric that was checked by science and special areas expertise (Appendix 1), and observation form.

Before beginning the STEM process, a rubric for the STEM activity was created by the researchers based on the literature (Amaya et al., 2015; Author, 2020; STEM School Progress Rubric, 2019; STEM Implementation Rubric, 2017). During the activity, the student's performance was observed and evaluated. The rubric was designed by 2 STEM experts, 1 classroom instructor and 1 special educator. In addition, the participants were followed by the researchers throughout the application. For this, an observation form that was checked by expertise (science and special areas) was created based on the literature on STEM skills (Duygu, 2018; Gökbayrak & Karışan, 2017). Observations were noted with the help of this form (Appendix 2). With the help of this observation form, it was aimed to determine the level of skills that inclusive students use during STEM studies and to reveal their needs. The participants were four 4th grade students attending the same school who were diagnosed with learning disabilities by the Guidance and Research Centre. While selecting the participants, support was obtained from the school administration and the guidance service, and care was taken to ensure that they had the same diagnosis and they were studying at the same level. Permission for the activity was obtained from the school administration and from the classroom teachers and parents of the participants, consisting of 2 girls and 2 boys. They were told the activities and they were included in the activities on a voluntary basis. STEM was expressed in its simplest form to them. During the activities, it was stated that science, technology, engineering and mathematics would be used together. The activities were carried out after school under the supervision of the researchers in the school psychological counselling service. The activities focusing on the subject of science were designed in the context of the learning objectives of the Next Generation Science Standards (NGSS) and the Turkish Ministry of National Education (MoNE). In addition, the activities were planned in a way that allowed the participants to collaborate and engage in peer learning.

The stages of the STEM activity are as follows:

1. Science Stage: “What are the elements that make up a circuit?” and “Can the dough that you will make really be used in a circuit?” In this context, the experts gave the students preliminary information about conductive and insulating materials and circuits and stated that they expected them to test this. With the question, “What are conductors and insulators?” their preparedness for the subject was tested. Again, when they were asked for examples of conductors and insulators, they gave answers such as “sea water” and “pool water”, and based on this, they were questioned why pool water and sea water conduct electricity. Similarly, they were asked to find answers to the question, “Can this process be done with play dough?”.

2. Mathematics Stage: The students used 4 process skills in the stage of mixing the play dough by weighing it in certain sizes. They also used mathematics intensively in the processes of boiling and cooling to a certain temperature and using the dough as a cable in the circuit.

3. Technology Stage: Technology, which is also expressed as everything that makes life easier, was used by the students throughout the activity. They continued their activities by using technological tools such as a beaker, precision balance, graduated cylinder, spirit stove, battery, LED lamp, and switch.

4. Engineering/design process: The students produced designs to make the play dough they had prepared a part of the circuit. They brainstormed about where to use the play dough in the circuit and discovered that it could be used instead of wires. At this stage, the participants discovered how they could use play dough correctly in the circuit. For example, with brainstorming such as “Seeing that play dough can be a conductive battery…” (participant A), “Let’s make play dough like a cable, okay?” (participant B), and “Where should the play dough stick to the bulb?” Participant D) they were able to predict how a correct circuit arrangement should be. Those who saw that the lamps did not light or that the DC motor did not work in the circuit construction decided that their designs were wrong. Designs that were unsuitable were redesigned and reintegrated into the circuit.

When they realised the inaccuracy of their designs in the engineering design cycle, they updated their designs again and tested whether or not they had achieved the result. In this process, the researchers made observations on the one hand and carried out their guidance duties on the other.

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METHODOLOGY AND MATERIALS

Methodology of Research

This study was carried out with 4 students (two girls, two boys) diagnosed with learning disabilities and was designed in a mixed design. According to Creswell (2012), a mixed method design refers to the collection and analysis of quantitative and qualitative data together. In this study, explanatory sequential mixed method design was selected because it is aimed to determine the effectiveness of STEM approach among the participants. In order to evaluate the effectiveness of the STEM activities carried out in the first stage in the context of the process and the product, separate semi-rubrics were applied for each participant. The second stage consisted of the qualitative part where opinions were taken and observations were made within the scope of the activity. At this stage, one-on-one interviews were held with the students and the processes and products were observed by the researchers.

Material and Procedure

The students kneaded mixtures of certain sizes (1 cup[240ml] of water, 1 cup[120gr] of flour, ¼ cup [75gr] of salt, 3 tablespoons of cream of tartar, 1 tablespoon of vegetable oil, and a few drops of food colouring) in a bowl (Figure 2). The students were informed about what the materials were, and where and how much they would use at which stage, and the use of materials was left up to them to use in a controlled manner.

Photograph 1. Materials used in the activity

Conductive Play Dough

Brightly coloured and extremely soft play dough, which has been the main material used in handicrafts for generations, is a material that encourages children to produce things. It can stimulate their imaginations while playing and allow us to explore their creativity. It was thought that by making some changes to the materials that made up the play dough, it could be used for different purposes, and it was imagined, “Why not make more than just insects, towers or dinosaurs?” Considering that the salt that is added can transform it into conductive circuits and that it can turn into a fun activity, the way to a science-oriented activity was also opened by enlivening the participants’ imaginations. Science is not too complicated for children as long as the aim is not to teach scientific concepts, principles or explanations. Providing opportunities for children to work on the materials and seeing how they react to the materials are among the priorities of science education (NGSS, 2022).

First of all, how to make a conductive play dough was explained. It was elicited how play dough can be conductive with examples such as sea water and pool water. It was understood that after salt dissolves, it enables the transfer of electrical energy in its medium. Then, the mixing, kneading and cooking process for the conductive play dough was begun (Photograph 2).

Photograph2a. Conductive play dough cooking process

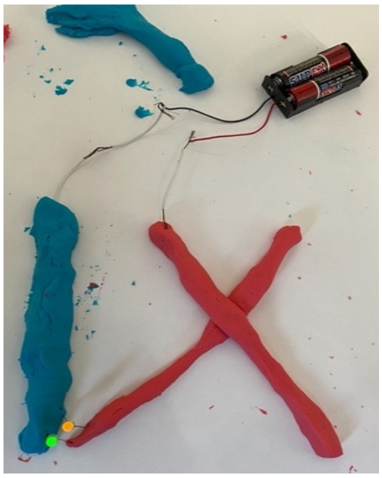
Photograph2b. Conductive play dough making process

The students cooked the play dough on a medium heat. They boiled the mixture until it thickened well, and then they left it to cool. They were given time to shape it by kneading it on a floured surface. Next, they identified the elements of an electrical circuit. They discussed the function of materials such as a LED lamp, DC motor, switch, wires, and battery in the circuit and their role in the conversion of energy (Photograph 3).

Photograph 3. Discussing the function of materials

By making a connection with daily life, they tried to understand and analyse the questions, “How does the electric current from the power supply operate the circuit elements? For example, the light bulb” and “So, when we build a circuit, how can we transfer the electrical energy to another circuit element without wires?” This was when they realised that the play dough would come into play, and they began their designs (Photograph 4).

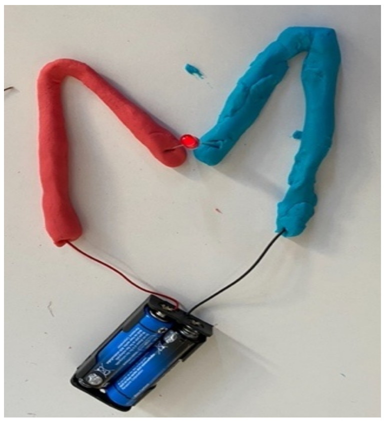
Photograph 4a. Examples of conductive play dough circuits



Photograph 4b. Examples of conductive play dough circuits

In the activity, the children designed simple electrical circuits using the dough they had mixed, kneaded, thickened and coloured. With the activity, they both had fun and constructed knowledge, and by using the disciplines of science, technology, engineering/design and mathematics together, the knowledge they learned was made more meaningful and permanent (Photograph 5).

Photograph 5a. Conductive play dough DC motor circuits



Photograph 5b. Conductive play dough LED lamp circuits

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CONCLUSIONS and SUGGESTIONS

STEM activities in which students with learning disabilities actively participate can be effective in their learning. The rubrics and observation notes that the researchers received throughout the activity, and the feedback received from the students, show that the activities they designed by doing and experiencing contributed to them. A maximum score of twenty-four can be obtained from the STEM rubric used in the activity. Participant A received a total of twenty-two points, participant B received a total of twenty points, participant D received a total of twenty-four points, and participant C received a total of twenty-one points. The participants received maximum scores from the parts using scientific and mathematical knowledge. It was determined that among the rubrics, the participants used their science and mathematics knowledge the most. This situation reveals that the use of collaborative approaches, especially with small groups, as a teaching-learning tool can be effective in fostering science learning outcomes in SLDs in the literature (Akarsu, et al., 2022). Therefore, while creating learning environments and planning instruction, individuals with special needs should be enabled to exhibit and develop their knowledge and skills, by taking their individual differences into account (Zorluoğlu & Sözbilir, 2017; Villanueva et al., 2012). In this context, performing STEM activities in a student-centred way and considering students' differences can enable permanent learning, particularly in subjects such as science and mathematics.

Especially for learning objectives to be given with integrated disciplinary approaches such as STEM, 1. pre-planning 2. the teacher's having a background related to STEM, and 3. a suitable learning environment are essential. When the literature was reviewed, it was determined that while teaching with SLDs, science teachers had problems in making adaptations in the curriculum, method and activities conducted during the lesson (Caseau & Norman, 1997). Moreover, special education teachers stated that the content and hours of the courses they took in undergraduate science teaching were insufficient, that they had problems in the adaptations to be made while teaching science concepts to ISNs due to the fact that the courses were mostly theory-oriented, that there were insufficient materials for the science course, and that the physical conditions of the classroom were unfavourable (Dedeoğlu et al., 2004; Tarhan, 2019). Similarly, special education teachers stated that due to the complexity of the concepts they encountered during science teaching, they experienced inability in terms of how to present these concepts (Smith et al., 2013; Tarhan, 2019). Therefore, in implementing effective teaching methods while presenting the curriculum set for SLDs, it is necessary to increase the competencies of both special education and science teachers who teach science to these students (Lynch et al., 2007). In their studies, Apanasionok et al. (2019), Taylor et al. (2019) and Therrien et al. (2011) emphasised that systematic and inquiry-based methods are effective in enabling permanent learning, especially in SLDs. In this context, it can be said that the STEM activity carried out was effective in terms of being systematic, problem-based, design-based and inquiry-based. Moreover, teaching approaches such as collaborative, video-based learning, STEM, and graphic editors for SLDs increased both students' science achievement and their attitudes towards science, and contributed to the development of their skills in reading and analysing science concepts (Botsas, 2017; Boyle, 2011; Thornton et al., 2015). This finding is in parallel with the result of the research. The fact that the researchers had STEM backgrounds, that the physical conditions were suitable, and that a pre-planning was made also enabled the teaching to be more effective. The rubrics and observation forms made while investigating the effectiveness of the instruction are evidence of this. By means of the process rubric, it was concluded that among the STEM disciplines in which they activated their analytical thinking skills, albeit partially, during the activity, the students were effective at an adequate level in all areas except for engineering design skills, and that they carried out the implementation step at a sufficient level. The deficient engineering design skills could have been rectified by giving students more time and providing them with a more comfortable environment. However, since the main purpose of the research was to enable permanent learning, not much emphasis was placed on this part. Three weeks after the activity, the students were interviewed one by one by one of the researchers (the special educator) and were asked questions about the STEM disciplines related to the activity, and it was determined that the students had not forgotten any of the information they had learned. It is significant that some of the students described this activity as "the most enjoyable activity in our lives" and also gave their feedback as "I remember every step performed and all the materials used in the activity". The responses given were recorded. This STEM-based teaching strategy, whose aim is to enable students to learn by doing and experiencing science and engineering activities as much as possible, supports the learning objectives of the Next Generation Science Standards in the following ways:

It encourages students to participate in science activities independently by providing equal learning opportunities within peer groups.

- It helps students become familiar with scientific knowledge and understanding through the use of tactile observation and physical models.
- It enables students to continue their conversations, demonstrate their curiosity and participate actively in collaborative problem solving, and to pose new research questions for future extended scientific research.

LIMITATIONS

This study was carried out with four students with SLDs. The activities were carried out in the guidance service outside of the classroom and could have been carried out in a more equipped environment over a longer part of time. For example, a support training room or a special training room. Morever, the effects of the activities carried out on the acedemic success of the students can also be observed. Thus, the effectiveness and permanence of the activities can also be measured.

RECOMMENDATIONS

Researchers who will carry out similar studies can be recommended to prepare the designed activities in the light of the IEP plan, more appropriate for the level of the student and in parallel with the curriculum. In addition, different activities can be designed in the context of providing students with desired behaviors.

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Appendix 1
STEM EDUCATION PROCESS RUBRIC

Evaluation criteria	4	3	2	1
Analytical Thinking Skills	He/she performed the activity in accordance with scientific processes.	He/she performed the activity partially in accordance with scientific processes.	He/she performed a very small part of the activity in accordance with scientific processes.	He/she did not perform the activity in accordance with scientific processes.
Using Scientific Knowledge	He/she used his/her scientific knowledge completely in the process.	He/she partially used his/her scientific knowledge in the process.	He/she used very little scientific knowledge in the process.	He/she did not use his/her scientific knowledge at all in the process.
Technology Usage Skills	He/she used technological tools adequately.	He/she partially used technological tools.	He/she made very little use of technological tools.	He/she did not use technological tools.
Engineering /Design Skills	His/her design skills were adequate for the activity.	His/her design skills were partially adequate for the activity.	His/her design skills were barely adequate for the activity.	His/her design skills were inadequate for the activity.
Using Mathematical Knowledge	He/she used his/her mathematical knowledge completely in the process.	He/she partially used his/her mathematical knowledge in the process.	He/she used very little mathematical knowledge in the process.	He/she did not use his/her mathematical knowledge at all in the process.
Application	All applications were made in a creative way.	All applications were made in accordance with the procedures.	All applications were partially made.	Problems were experienced in all applications.

Appendix 2
OBSERVATION FORM

	Questions	**Yes**	**No**
1.	She/he actively participated in group work.		
2.	She/he carried out the tasks.		
3.	She/he didn't shy away from taking responsibility.		
4.	She/he worked in collaboration.		
5.	She/he wasn't distracted throughout the activity.		
6.	She/he was in touch throughout the activity.		
7.	She/he did not exhibit any negative behaviour during the event.		
8.	At the end of the activity, she/he turned the design into a product.		

Appendix 3
STEM INTERVIEW FORM

Student Code: A/B/C/D
1. Do you think that the STEM activity we carried out contributed to your lessons?
If your answer is Yes, which subject do you think it contributed to?
2. Which STEM field did you use most in the activities we carried out?
Science, Mathematics, Technology, Engineering or Art
3. How did you feel during the activity??
Excitement, happiness, worry, sadness, or surpris

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Assessment of STEM Projects: Tacit Perspective of Turkish Science Education

Hakkı İlker KOŞTUR

ABSTRACT

Theoretical Article

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With the worldwide spread of STEM education, which is considered as one of the most important developments of the 21st century in the field of education, the question of how to assess STEM education activities has emerged. In STEM education, where many interdisciplinary learning outcomes are applied together and where the learning process is more important, it is natural for the traditional summative assessment methods to lose their validity. In Turkey, the 2018 science course curriculum was updated with the components of STEM education and the importance of process assessment was emphasized, but there is no detailed explanation given on how to do it. However, formative assessment was discussed in detail in an earlier Turkish science curriculum. In this article, discussion is presented on how to use formative assessment in STEM education with the aid of 2005 Turkish science curriculum together with examples from various resources.

Keywords: Formative assessment, Science curriculum, Science teachers, STEM education, STEM projects

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INTRODUCTION

Scientific knowledge can be replaced by new knowledge over time. Change frequently manifests itself also in educational sciences, and both in curricula worldwide and in academic studies, it can be witnessed how fast knowledge can change. The needs of the countries, the results of academic studies, new teaching approaches emerging in the world and many other variables affect each other mutually, and as a result, change is inevitable.

Scientific literacy is an important educational aim in all over the world. It has been almost two decades when Turkey aimed scientific literacy for all individuals. With the 2005 science and technology course curriculum (MoNE, 2005), in which important reforms were made on science courses, scientific literacy officially centered on the science education and the subsequent science curricula have implemented and maintained the similar perspective in 2013 (MoNE, 2013) and 2018 (MoNE, 2018). Although the understanding of scientific literacy is maintained, the ways to achieve this goal are developing continuously.

Science-Technology-Engineering-Mathematics (STEM) education approach, which is one of the most important subjects in the field of education in recent years (Land, 2013), contains many different teaching perspectives. Although it does not have a single definition and application method, it has been highly adopted by the education community and has yielded positive results. This interest was also reflected in the Turkish science course curriculum. Although the STEM statement was not clearly presented in the curriculum which was initiated in 2018, when the structure of the curriculum is examined, it can be seen that it contains many skills, subjects and concepts related to STEM education. In the curriculum, engineering and design skills were presented as a field on its own while the entrepreneurship was added to the domain of life skills together with the innovative thinking. In addition, they are defined in the science, engineering and entrepreneurial applications section.

Engineering and design skills have been described as an area that includes the ability of students to reach the level of inventing and innovating, creating products with the knowledge and skills they have acquired, and developing strategies on how to add commercial value to these products with an interdisciplinary perspective (MoNE, 2018). In the science, engineering and entrepreneurship applications section, students are expected to identify a need or problem for daily life among the subjects of science, design a product or develop existing products by taking into account criteria on materials, time and cost. The product development process will be carried out in the school environment by using scientific method and scientific process skills, and marketing, advertising and promotion strategies will be established for the product in question in order to develop entrepreneurial skills (MoNE, 2018).

Although STEM education is not limited to the science, technology, engineering and mathematics majors that give it its name, it is associated with and can be applied in various fields. In addition, robotics and coding applications have become an important part of STEM education. In sum, problem and project-based product design is an important aspect of STEM education. Today, many studies have been carried out about STEM education and significant experience has been gained both in the world and in Turkey.

2018 science curriculum was associated with STEM education which depends on problem and project-based product design. In such teaching methods, it is important to consider the process together with the result, and it is not possible to carry out the assessment with traditional methods and techniques. Nevertheless, it is a widely encountered case that teachers choose to assess through traditional methods contrary to the expectations of active learning processes (Akiri et al., 2020). In the science curriculum of 2018 (MoNE, 2018), it is recommended that assessment should be made during the education process and it is also emphasized that summative assessment alone will not be sufficient. Such process based assessment is known as formative assessment. Contrary to the summative approach which is basically assessing the knowledge at the end of a process (El Nagdi & Roehrig, 2022), formative assessments help teachers know if there is a need for reteaching or remediating or if the students already have enough knowledge on the topic (Margot & Kettler, 2019). Moreover, formative assessment has positive effects on motivation and attitudes towards STEM-based education (Jeong et al., 2020). Although assessment in STEM is relatively new research area (Donmez, 2020), summative assessment rather than formative assessment is not a new concept for science education in Turkey. This assessment approach was defined by the science and technology course curriculum of 2005 (MoNE, 2005), in which performance assignment was used and evaluated with rubrics.

Rubrics are important tools in formative assessment and useful in active learning pedagogies in order to measure critical thinking and science process skills together with learning outcomes (Reynders et al., 2020). In addition, self, group and peer assessment methods were presented which can promote learning performance in STEM courses (Wang & Chiang, 2020) have been practiced in Turkish science courses since then.

In order to find an answer to the question of how the assessment in STEM education should be, firstly, the developments in STEM education regarding assessment, followed by the science and technology course curriculum of 2005 in which the formative assessment is emphasized in detail, and the curricula applied subsequently are included in the investigation with the ready-to-use assessment examples.

Related Literature

In order to investigate on the assessment in STEM education, it will be useful to consider the recent developments in the related literature. STEM education has attracted a high level of attention all over the world since the moment it occurred in the literature, and has become very popular in various fields of education. STEM education has also become popular academically. For instance, Tyler-Wood et al. (2010) created two scales, the STEM perception scale and the STEM career interest scale, and conducted their validity and reliability studies. The scales have been developed for use in a wide range of ages; MacPhee and Canetto (2013) compared the academic achievement and self-efficacy levels of individuals studying in STEM fields in terms of variables such as ethnic origin and socio-economic status in their longitudinal study; Brown et al. (2016) compared secondary school students' self-efficacy levels towards STEM, including their interests and perceptions of STEM and different variables such as gender and collaborative work characteristics; Haciomeroglu and Bulut (2016) carried out the adaptation study of the STEM Teaching Intention scale prepared by Lin and Williams (2015) into Turkish. The scale was named Integrated STEM Teaching Orientation Scale of Pre-service Teachers and it was intended for pre-service teachers in the primary school teaching department. In another study Sarakorn et al. (2017) examined the effect of STEM activities on high school students' academic achievement, creative thinking skills and attitudes towards science as a result of 14-hour STEM education and reported that the results showed statistically significant differences.

The general focus of research on assessment in STEM education is on measuring some affective characteristics of STEM. There are few studies on the evaluation of STEM activities, projects and products. The most important resources in this regard are the educational reports of the countries (Howes, et al., 2013; MoNE, 2016; MoNE, 2017; Altunel, 2018) and websites that share STEM-related lesson plans and course contents, which were established to guide teachers (Wiggins, 2015; Jolly, 2016).

Howes et al. (2013) prepared a report on the state of science and mathematics teaching in England, setting strategies for the next 20 years. In the report, the importance of process evaluation was emphasized, and it was stated that students' skills towards entrepreneurial tasks, their ability to work in collaboration and their attitudes should also be included in the evaluation. In order for this kind of assessment and evaluation to be useful, it has been suggested to use innovative assessment methods that can measure more learning outcomes such as e-portfolio, group and peer assessment (Howes et al. 2013). Margot and Kettler (2019) conducted a literature review and analysed 25 studies which examined teachers' perception on STEM integration in education. They reported that teachers indicated that there were lack of quality assessment tools, lack of enough standardized classroom assessments, and lack of formative assessments. In addition, there was a concern on group grading and teachers expressed that they were unsure about grading members separately in a group. Gao et al. (2020) investigated 49 empirical STEM education research articles in terms of interdisciplinary nature and the assessment methods that were used in the research designs. I was seen that although most of the studies were based on engineering design, 8 of them focused on assessing the knowledge alone. Most of the studies lacked assessment on the improvement of student's interdisciplinary understanding or skills. Akiri et al. (2021) investigated 125 Israeli STEM coordinators and teachers' both teaching and assessment methods. Teaching methods included lectures and presentations followed by class discussions and collaborative duties. Tests with open-ended and close-ended questions leaded assessment methods, followed by project portfolios and experiment reports. It was seen that more STEM-specialized participants tended to use formative assessment methods. El Nagdi and Roehrig (2022) compared the ideal assessment methods in STEM education with the actual assessment methods in the classrooms of STEM schools in Egypt through survey and interviews. They concluded that there more effort should be spent in creating formative assessment rubrics in terms of measuring collaboration, communication, critical thinking, problem solving, creativity in order to develop engineering design and 21st century skills.

Literature review shows a need for progress in formative assessment in STEM education. In accordance, this study aims to provide several ready-to-use formative assessment examples some of which were presented in the Turkish former and constructivist initiator science curriculum of 2005.

Assessment Applications Related with the STEM Education Approach

A STEM education report was prepared by the Turkish Ministry of National Education, General Directorate of Innovation and Educational Technologies (MoNE, 2016). In the report, it is stated that measurement tools that can measure the mental processes of students in stages such as research, inquiry, production and making inventions should be developed. In addition, the importance of process assessment and use of rubrics was emphasized (MoNE, 2016).

Following the STEM education report, the General Directorate of Innovation and Educational Technologies of the Turkish Ministry of National Education published a STEM Education Teacher Handbook and made it available to teachers (MoNE, 2017). In the report, it is suggested that techniques such as project plan, resource usage table, time management table, project task distribution chart and weekly activity reports should be used to monitor the process in order to make process evaluation in STEM projects. These reports are similar to the use of portfolios. In addition, a rubric was included under the title of evaluation of the STEM project plans (Table 1).

Table 1. Assessing STEM project plans (MoNE, 2017)

Group Members	Innovation (0-10 points)	Importance (0-10 points)	Solvability (0-10 points)	Applicability (0-10 points)	Suitability (0-10 points)	Total Score
Grand Total Score of the Project						

Altunel (2018), prepared the STEM Education and Turkey: Opportunities and Risks report. The report explained that the general understanding of assessment is based on the classical examination of testing approaches in Turkey and suggested the need to develop alternative assessment methods.

The web site *More than a Worksheet* was established by a teacher to support other teachers. It was stated in the web page that STEM education is not a traditional teaching method and therefore it is not suitable for traditional assessment and evaluation methods (Wiggins, 2015). On this page, teachers are recommended to use creative assessment and evaluation methods such as photographing, portfolio, and diary. In addition, rubrics in Tables 2 and 3 are given as an example for teachers' use:

Table 2. STEM Rubric (Wiggins, 2015)

TASK				
Grading Myself				
	Unsatisfactory Effort (0 points)	Effort Needs Improvement (1 points)	Satisfactory Effort (2 points)	Outstanding Effort (3 points)
I contributed to the team work.				
I exhibited scientific thinking.				
I maintained a positive attitude.				
I completed the building task.				
I reflected on my work.				
Grading My Team				
My team worked well together.				
My team displayed problem-solving skills.				
My team had a positive attitude.				
My team completed the building task.				
My team discussed and reflected on our work.				
Graded by My Teacher				
Student cooperated with team.				
Student exhibited scientific thinking.				
Student maintained a positive attitude.				
Team completed the building task.				
Student reflected on work.				

Table 3. Engineering Learning Scale (Wiggins, 2015)

WHAT TYPE OF ENGINEER ARE YOU?	
4	Thriving Engineer I used critical thinking skills to meet the challenge in a unique and creative way.
3	Growing Engineer I used critical thinking skills to meet the challenge according to the guidelines.
2	Sprouting Engineer I used critical thinking skills to attempt the challenge, and I still have some work to do to meet the challenge.
1	Budding Engineer I am beginning to use critical thinking skills in order to meet challenges, and I need more practice in order to complete this one sufficiently.

Jolly (2016) gave advice on measurement and evaluation in STEM education on the web page named Education Week: Teacher. In the article, which emphasizes the question of the perspective of students and what skills they acquire when using the STEM education method, the following points are summarized for a successful STEM course:

- Choosing real world problems while planning STEM lessons,
- Using the engineering design process in problem solving,
- Asking thought-provoking questions to develop an interdisciplinary perspective,
- Use of self-assessment, group and peer assessment techniques,
- Using communication, creativity and scientific process skills in STEM projects,
- Following the affective characteristics of students such as attitude and self-efficacy,
- To know the properties of project-based learning strategy. (Jolly, 2016)

With the effort to carry out formative assessment in STEM education, along with current developments on the subject, discussion on formative assessment are presented which can be used by practitioners directly or by adapting to their own situation. Many examples that can be used in this way are included in this article. In addition, the Turkish science and technology course curriculum of 2005 was examined. The instructions in the curriculum are works of a large study group of educational researchers and teachers considering needs of the country and the developments in the world. The information given in this section is related to the formative assessment of STEM projects and limited to a certain amount of examples. The accuracy of the adaptation, development or evaluation to be made for the situation in which these samples will be used, is strongly depended on the practitioner.

Assessment Perspective in the Turkish Science and Technology Curriculum of 2005

Assessment according to primary school science and technology curriculum (MoNE, 2005) is determining the learning situation of students and determining the level of achievement of the learning outcomes in the curriculum; providing feedback for meaningful learning; identifying future learning needs; informing parents about children's learning levels; and it should be done for reasons such as following up whether the teaching strategies and curriculum content used are balanced and effective. The curriculum was prepared on the basis of the constructivist teaching approach and student-centered education was preferred instead of teacher-centered, so it was emphasized that alternative approaches should be used in the education and training process compared to traditional assessment and evaluation methods, and it was emphasized that it was necessary to enable multiple assessment in which knowledge, skills and attitudes could be displayed. The measurement and evaluation principles emphasized in the curriculum are shown in Table 4.

Table 4. Assessment Principles in the Turkish Science and Technology Curriculum of 2005 (MoNE, 2005)

Less emphasized	*More emphasized*
Traditional assessment methods	Alternative assessment methods
Assessments independent of teaching and learning	Assessment as part of teaching and learning
Assessment of memorized knowledge	Evaluating meaningful and deeply learned knowledge
Assessing fragmented and unconnected knowledge	Assessing interconnected, well-structured knowledge network
Evaluating scientific knowledge	Assessing scientific understanding and logic
Assessment to learn what the student does not know	Assessment to learn what the student has understood
Assessment activities at the end of the semester	Ongoing assessment activities throughout the semester
Teacher's assessment only	Group assessment and self-assessment with the teacher assessment

In Table 4, the principles of assessment, which are aimed to be emphasized less and more during the implementation of the curriculum, are determined. When these principles are examined, it is seen that a successful evaluation should be a process-oriented, active, sensitive and important mechanism. The curriculum also distinguishes between traditional and alternative measurement and evaluation techniques (Table 5).

Table 5. Traditional and alternative assessment techniques (MoNE, 2005)

Traditional techniques	*Alternative techniques*
Multiple choice tests	Performance evaluation
Right and wrong questions	Student product file (portfolio)
Matching questions	Concept maps
Completion (fill in the blank) questions	Structured grid
Short-answer written exams	Diagnostic branched tree
Long-answer written exams	Word association
Question and answer	Project
	Drama
	Interview
	Written reports
	Demonstration
	Poster
	Group and / or peer assessment
	Self assessment

In the curriculum, it was especially emphasized that alternative assessment and evaluation techniques are important for formative assessment: "Since alternative measurement and evaluation techniques evaluate not only the product but also the learning process, it ensures that students have responsibility for learning and be proud of what they have learned (MoNE, 2005).

In most of the alternative assessment techniques, especially performance evaluation and portfolio, rubrics are used to determine the students' conceptual knowledge or proficiency level in a given task. Rubrics can be used in two ways: holistic and analytical (MoNE, 2005). In the curriculum, it was emphasized that when using these assessment methods, students should express themselves in the best way without suppressing their creativity and ability to produce original thoughts. In addition, assessment rubrics should be shared with students and/or parents when necessary (MoNE, 2005). These explanations show that the process evaluation should be carried out within certain standards and transparency.

Alternative assessment methods are discussed respectively in the curriculum. Methods such as interviews, observations, oral presentations, and projects are discussed briefly. The main purpose of applying various assessment methods together is to ensure that the triangulation, which is frequently used in data collection in scientific research. Using more than one measurement tool with triangulation, fosters to observe a subject from many different angles and increases the validity and reliability of the data obtained (Vanderstoep & Johnston, 2009). In addition, it can be expected that students will develop many skills such as communication, teamwork, problem solving, and critical thinking as a result of making oral presentations individually or as a member included in project groups. In the following sub-sections prioritized assessment methods in the 2005 primary school science and technology curriculum are presented.

Self Assessment

Self-assessment is important for students to discover themselves, to see their strengths and weaknesses, and to see that they are a part of the assessment process. It has been stated that the more individuals experience self assessment, the more they will become more accurate in assessment (MoNE, 2005).

Peer Assessment

Peer evaluation is used for students to assess the work prepared by their friends. Peer assessment contributes to the development of critical thinking skills (MoNE, 2005).

Rubrics

A rubric is a tool developed for scoring a study and consisting of criteria that define performance. The use of this method creates a sense of quality and responsibility based on the pre-determined standards and criteria, makes the time spent for evaluation more efficient and shows students how they are going to be evaluated (MoNE, 2005). In order to develop a rubric according to the curriculum, it is important to determine the purpose for which the rubric will be developed, what to evaluate, the proficiency levels, behaviors and skills, and the distinction between categories clearly. An example to a holistic rubric is given in Table 6. The analytical rubric is used by evaluating the different steps of a study one by one and calculating the total score (MoNE, 2005).

Table 6. Holistic Rubric (as presented in MoNE, 2005)

Score	Criteria
4	The category showing that the subject is well understood, supported with logical reasons, examples are presented by establishing different connections between events, and there are no contradictory explanations.
3	The category that shows that the subject is understood, supported with logical reasons, but insufficient.
2	The category that shows that the subject is largely understood, that the proposed ideas are supported but insufficient, and that there are contradictory explanations in the narrative.
1	The category that shows that the subject is poorly understood and inadequate examples are presented.

Portfolio (Student Product File)

A portfolio is a collection that shows students' efforts, experiences, and reflections related to the desired study. In addition, portfolio is an evaluation method that enables students and their friends, as well as teachers and parents to observe the process of the student. It is aimed to contribute to issues such as developing self-discipline and sense of responsibility, providing sound evidence for evaluation, observing the level of realization of the objectives of the curriculum, and encouraging students to participate in evaluation (MoNE, 2005). There is more information about portfolio including example product files in the reference curriculum.

Performance Assessment

Performance evaluation is a type of homework that is evaluated with rubrics, which results in an observable performance or a tangible product by using the knowledge and skills of the students and their problem-solving skills for daily life. In addition, with effective use of rubrics, a road map will be drawn for the student's performance assignments in which students will be informed of the assessment criteria and the scoring levels (MoNE, 2005).

In the curriculum (MoNE, 2005), concept maps, V-Diagrams, structured grids, diagnostic branched trees, attitude scales and multiple choice tests are explained in detail, apart from the sub-topics explained above. Sample assessment forms presented in the curriculum for various purposes are given below. The first one is a self assessment form which is shown in Table 7.

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Table 7. Self Assessment Sample Form - I (MoNE, 2005)

Skills	Scoring levels		
	Always	Sometimes	Never
1. I listened to others and their suggestions.			
2. I followed the instructions.			
3. I encouraged my friends without hurting their feelings.			
4. I have completed my duties.			
5. I asked questions when I did not understand.			
6. I supported group members in their studies.			
7. I used my time wisely during my studies.			
8. I used different materials during my studies.			
9. What did I learn from this activity?			
10. How did I help group members during this activity?			
11. Things I did best during this activity:			
Other comments:			

There is another self assessment form given in the curriculum which includes open-ended questions rather than the mixed form in the first one, shown in Table 8.

Table 8. Self Assessment Sample Form - II (MoNE, 2005)

What did I do in this activity?
What did I learn in this activity?
In which parts of this activity I was successful?
Which parts of this activity were difficult for me?
What did I encounter that I did not expect in this activity?
If I were to do this work again, I would do it this way:

The first group assessment form is presented in Table 9 which contains likert-type statements to be graded by the students.

Table 9. Group Assessment Sample Form - I (MoNE, 2005)

Skills	Scoring Levels				
	Never	Rarely	Sometimes	Often	Always
Group members help each other.					
Group members consider each other's thoughts.					
Each member of the group takes part in the work.					
Group members respect each other's thoughts and efforts.					
Each member of the group discusses in interaction with each other.					
Group members share their results with each other.					
Group members fulfill their individual responsibilities.					
Group members discuss their knowledge with others.					
Group members trust each other.					
Group members encourage each other.					
Group members take care that the right to speak is shared fairly.					
When there are conflicting views in the group, those in the group open them up for discussion.					
Group members form a consensus on the subject they are working on.					
The group works efficiently.					
Group members enjoy working together.					
Other comments:					

The second group assessment form includes statements to be graded from 1 to 5, presented in Table 10.

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Table 10. Group Assessment Sample Form II (MoNE, 2005)

Name of the students	Readiness to work	Listening to the others	Sharing responsibilities	Supporting group members	Participating in discussions	Justifying their opinions	Respecting differing opinions	Willingness to take charge	Using time efficiently	Completing assignments	Archiving assignments	Total score
Other comments:												

(Scoring levels: 5 = Excellent, 4 = Good, 3 = Fair, 2 = Acceptable, 1 = Weak; The number of horizontal lines will be increased by the number of students to be evaluated.)

The curriculum also presented a detailed form to assess projects from different aspects which was shown in Table 11.

Table 11. Project Assessment Sample Form (MoNE, 2005)

Skills	Scoring Levels				
	Weak	Acceptable	Fair	Good	Excellent
	1	2	3	4	5
I. PREPARATION PROCESS					
Determining the purpose of the project					
Making a work plan suitable for the project					
Distributing tasks within the group					
Identifying needs					
Gathering information from different sources					
Carrying out the project according to plan					
Performing teamwork					
Carrying out the project work willingly					
SCORE					
II. CONTENT OF THE PROJECT					
Using the language decent and correctly					
Accuracy of information					
Analyzing the collected information					
Making inferences from the information obtained					
Organizing the collected information					

Demonstrate critical thinking skills	
Using your creativity ability	
SCORE	
III. PRESENTATION OF THE PROJECT	
Speaking the language correctly and properly	
Giving satisfactory answers to questions	
Presenting the topic in a way that engages the audience	
Supplementing the presentation with targeted material	
Using fluent language and body language in the presentation	
Completing the presentation in the given time	
Confidence during the presentation	
Presenting with good manners	
SCORE	
TOTAL SCORE	
Comments of the teachers	

(Note: Above 1-5 are degrees. The important thing here is to increase the success of the students to the level of 5 (very good)).

Sample peer assessment form is given in Table 12, which allows group members to evaluate each other in a project.

Table 12. Peer Assessment Sample Form (MoNE, 2005)

	Always			Beginning of the project			End of the project			Never		
Members in my group	Me	Member 1	Member 2	Me	Member 1	Member 2	Me	Member 1	Member 2	Me	Member 1	Member 2
Voluntarily articipates in the activity												
Completes his/her duty on time.												
Collects and presents information from different sources.												
Respects the opinions of her group members.												
Uses positive language when warning her friends.												
Is careful and meticulous when using materials.												
Does not waste materials while using.												

Works clean, tidy and orderly (replaces the tools he/she uses, cleans the dirty ones, etc.).	
Speaks clearly when discussing the results, understands what is being discussed.	

The last sample form was an experiment assessment form which is shown in Table 13. It can be concluded in the form that experiments are highly related with the science process skills in the curriculum.

Table 13. Experiment Assessment Sample Form (MoNE, 2005)

Name of the student	Identifying the research topic	Identifying the dependent variable	Identifying the independent variable	Identifying the controlled variable	Choosing the necessary materials and equipment	Using the appropriate measuring tool	Recording data suitable for the purpose of the	Data processing	Interpretation and inference	Presenting the findings

(The number of horizontal lines will be increased by the number of students to be evaluated)

It can be seen that science and technology curriculum (MoNE, 2005) includes important issues such as performance assignments, process assessment, project, experiment, product assessment, self assessment, group assessment and peer assessment, portfolio which makes this curriculum the most extensive and detailed one among others. 2013 and 2018 science course curricula, which were implemented afterwards, were also prepared with a similar structure and constructivist vision. It is known that the new curricula were prepared on the basis of the 2005 curriculum. Since there is not as much information as in the 2005 curriculum in 2013 and 2018 curricula, current curriculum knowledge will not be sufficient for educators. For this reason, educators should be provided with this information through science teaching courses in faculties, various publications and in-service training.

In the science course curriculum, which started to be implemented in 2013, problems, projects, argumentation, and cooperative learning methods were recommended to use in science teaching (MoNE, 2013).

The assessment approach of the 2013 curriculum is based on process evaluation, similar to the previous curriculum (MoNE, 2013). In the curriculum, it was indicated that the numerical data obtained with traditional measurement tools does not make sense on its own, and it was suggested to use complementary measurement tools and techniques. It is important to evaluate student performance not only with knowledge based assessment but considering about other areas such as skills, affective domain and science-technology-society-environment (STSE) issues, and to include self and peer-assessment methods in the process evaluation. In addition, it has been indicated that technology can also be used to evaluate process and performance (MoNE, 2013). There is no more detailed information about these concepts in the curriculum. Therefore, in order to understand the concepts in question, the previous curriculum should be examined.

The teaching strategies and methods adopted in the 2018 curriculum, which is based on problem and project-based product design, are similar to the 2013 curriculum, and the aim of producing input to the economy by integrating science with engineering applications was considered. In the curriculum, it was emphasized that teachers' originality and creativity should be at the forefront instead of the approach explained in the curriculum in order for assessment methods to be effective, and the following principles were included (MoNE, 2018):

- The assessment methods in the curriculum are for guidance only, and technical and academic standards should be followed in the preferences of the practitioners,
- Since the characteristics of individuals such as interests, attitudes, values and success may change over time, the assessment results should not be handled at a single time and seperately, but as a whole, taking into account the changes along with the process followed,
- A student's academic development cannot be assessed with a single method or technique,
- Not only cognitive measurements are sufficient for measurement, but also feelings (affective domain) and skills should be measured,
- Multi-focused assessment should be carried out with the active participation of teachers and students.

As can be inferred from the information given, formative assessment has an important place in Turkish science education. Detailed information on this subject was presented in the 2005 curriculum and summarized in this article. Regarding the question of how assessment should be done in STEM education, the approach of science education curricula to some concepts such as process, performance and product assesment is as explained above. In particular, rubrics, self, peer and group evaluation forms, portfolio, project and experiment evaluation subjects can be developed with the creativity of the practitioners in order to become suitable for use in STEM activities.

Technological Design Cycle

Another noteworthy issue in the 2005 curriculum was the technological design cycle which is a simple problem solving algorithm in product development and material design. As the design concept is highly related with STEM approach, technological design cycle is discussed in this article. The 2005 curriculum included a separate chapter about technological design and it was examined under science-technology-society-environment (STSE) issues with the following learning outcomes (MoNE, 2005):

- Understands that technological design is a process consisting of various stages such as determining the features of the design, making preliminary design and division of labor, making use of model and simulation, trial production and evaluation of the product,

- Realizes that in the development of technological products various types of resources can be used: imagination; creative thinking; culture and traditions; mathematical knowledge; knowledge obtained through science about the natural phenomena; and the ability of people to be aware and to combine knowledge; regardless of their source, facts and materials that may seem completely unrelated at the beginning.

In the 2005 curriculum, there are technological design activities where students are asked to develop technological solutions for a particular problem, which are recommended to be implemented when they deem necessary and students are expected to use the technological design cycle. Technological design cycle steps are presented to be used in these activities and it is stated that educators can apply them flexibly (MoNE, 2005).

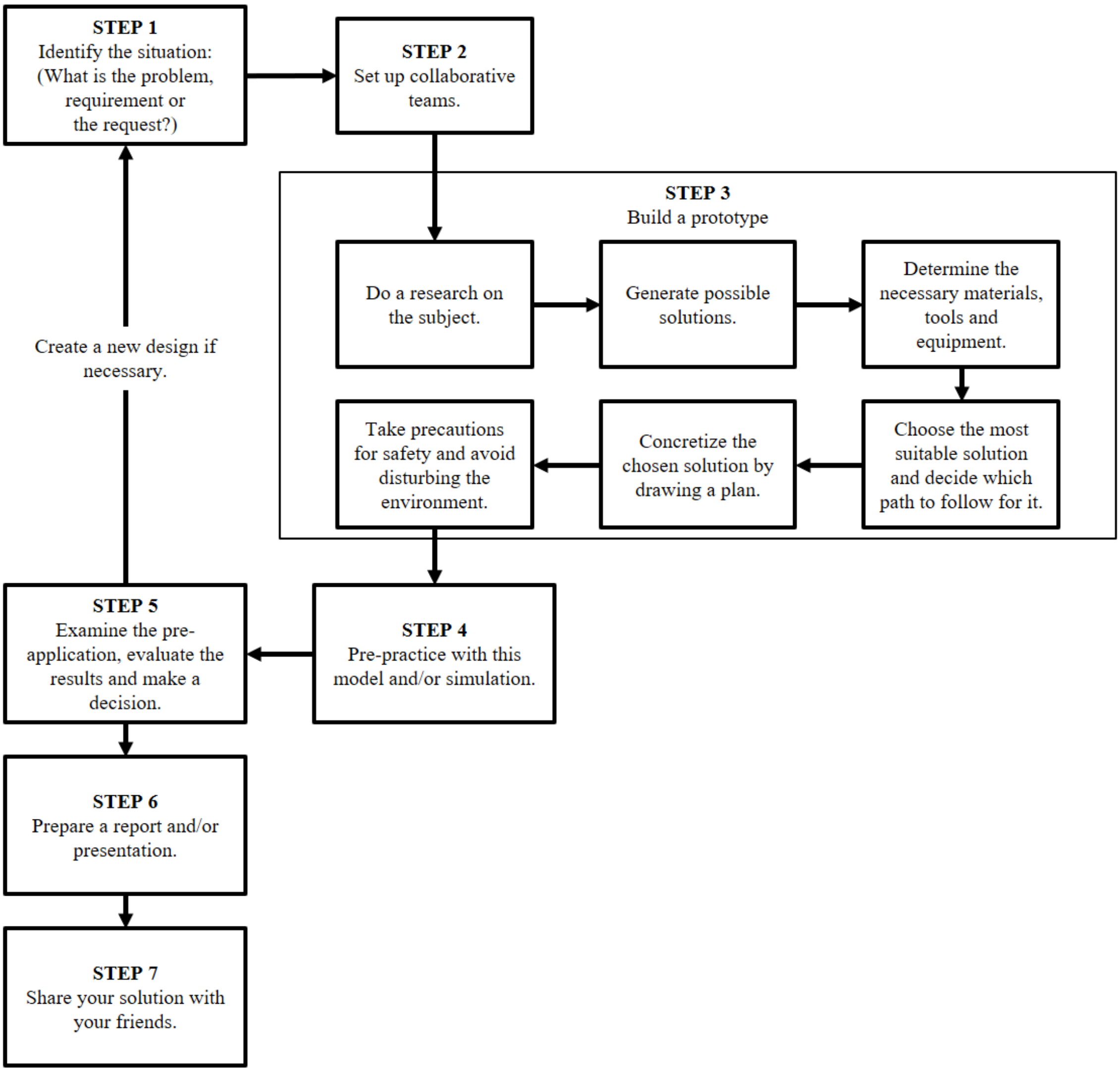

Figure 1. Technological design cycle (MoNE, 2005)

With technological design, students are expected to improve themselves in issues such as problem solving skills, gathering information about the content of the problem, generating ideas and preparing draft drawings related to these ideas, preparing models, designing and developing products, reporting and presenting their work (MoNE, 2005).

When the technological design cycle is examined, it is seen that it is similar to the explanations for product development in the science curriculum that started to be implemented in 2018. As in the applications for STEM education, similar to the technological design applications, it is aimed to take a multi-faceted approach to product design, which is based on problem solving from students' daily lives. Therefore, it would be beneficial for educators to have information about the technological design cycle for their STEM applications. In addition, technological design cycle can also be used for self-assessing of STEM project plans with minor modifications.

Conclusion and Suggestions

In line with the needs of the countries, new skills emerge continuously and they are expected to be taught to students, and as a result, changes are inevitable for the traditional teaching methods. Changes in teaching methods also change the understanding of pedagogy, and the way the lessons are taught and the evaluation of student performance is shaped according to this understanding. In the 21st century, the main duty of teachers is not to teach, but to guide students to solve daily life problems using the scientific method together with developing skills, feelings, and awareness for the STSE issues. Guidance duty is directly related to teachers' abilities and creativity. This can be clearly observed in any curriculum.

From the moment STEM education approach emerged, it has been met with great interest and excitement, and everyday, new answers have been given to the question of how STEM education should be applied. Today, teachers have been presented with a large number of resources that they can use in STEM education and these resources continue expanding. As in every teaching and learning situation, it is necessary to determine whether the method followed is effective or not in STEM education. In other words, it is a necessity to determine how the assessment in STEM approach should be made.

Research emphasize the need for more focus on the assessment strategies in STEM approach (Donmez, 2020; El Nagdi & Roehrig, 2022; Margot & Kettler, 2019). Therefore, this article discusses and seeks answers to the question of how assessment in STEM education should be carried out. The question has been discussed from both national and international perspectives. Current international sources draw attention to the use of techniques such as process evaluation, self-assessment, peer and group evaluation, portfolio and rubrics for a successful assessment in STEM education. These assessment and evaluation techniques are suggested by the current reports (Howes, Kaneva, Swanson, & Williams, 2013; MoNE, 2016; MoNE 2017; Altunel, 2018) and other sources (Wiggins, 2015; Jolly, 2016).

On the other hand, there were reports which were contrary to the formative nature of assessment of STEM education approach. For instance, El Nagdi and Roehrig (2022) found out that most STEM classrooms used traditional assessment systems; Margot and Kettler (2019) discussed a need for more quality curricula which include formative assessment techniques teachers can use to assess their students' conceptual understandings. Turkish former science curriculum (MoNE, 2005) is a good example for such a concerns.

It was seen that how assessment in STEM education should be carried out question found fragments of answers in science and technology course curriculum where assessment was discussed in detail (MoNE, 2005). Therefore, it can be assumed that teachers, who are valuable practitioners and guides, are not far from the assessment methods explained in this article. However, this article is believed to be useful to readers for reasons such as the abolition of the 2005 curriculum since 2013, the fact that teachers who graduated after this date and current teacher candidates, and teachers working in different branches to apply STEM education, which is an interdisciplinary approach, probably do not have enough knowledge about the 2005 curriculum.

The skills and characteristics of the practitioner will play an important role in the direct or adaptive use of the examples given in this section. Formative assessment requires much more attention, motivation and dedication than summative assessment. In order to obtain a high level of efficiency from the assessment, it is important that the practitioners increase their experience in this regard. In addition, as El Nagdi and Roehrig (2022) summarized, elaborating assessment in STEM education should be given more attention in both research and policy levels.

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Consent for Publication

The authors do consent for publication of this work.

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Does *Green Space* Influence Students' Academic Performance and Pro-environmental Behavior? An Empirical Study at a Pro-environmental University

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ABSTRACT

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Green Space has become a central awareness of higher educational institutions as it is expected to create a better atmosphere to study. This study aimed to examine the effects of students' perception of Green Space on their Academic Performance and pro-environmental behavior. It was a quantitative study; there were 705 students in the population and 256 student participants. The data were collected by distributing the questionnaire. After the questionnaire was tested for validity and reliability, the data were analyzed with SPSS version 21. The results showed that students' perception of Green Space (X) had a positive but insignificant effect on Academic Performance(Y1). Furthermore, the Perception of Green Space (X) positively and significantly affected pro-environmental behavior (Y2). Therefore, it is recommended that higher education institutions improve their pro-environmental behavior by committing to Green Space. Then, educational institutions are concerned with other factors, such as the lecturers' competencies, interests, and passions, and the infrastructure to improve students' Academic Performance.

Keywords: Green Space; Academic Performance; Pro-Environmental Behavior;

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INTRODUCTION

Everyone loves a green and fresh environment. The beautiful earth, green leaves and trees, and beautiful colors of various flowers are pleasing to humans. Nevertheless, land, sea, and air damage happens as time passes. ICSU Scoping Group (International Council for Science, 2005), in its report, emphasized that human intervention in the environment makes nature worse. Changes in land increase the risk of landslides or floods. The destruction of mangroves can increase the vulnerability of coastal areas due to the inability to withstand waves, pollutant emissions, and greenhouse gases; as a result, using household appliances can increase the frequency of extreme weather events. Therefore, various parties began to campaign for the greening or environmentally conscious movement to improve the environment for humans in the future.

Institutions, especially educational institutions in Indonesia, are expected to be able to make their students aware of the importance of a green environment. Environmental education is part of Indonesia's mainstream education system and is integrated into school curricula and after-school activities (Nada, Fajarningsih, & Astirin, 2021; Noeswantari & Christanti, 2005). Several studies have examined the relationship between *Green Space* and student academic performance. Browning and Rigolon (2019) found that the effect of *Green Space* on Academic Performance was not consistent; from 13 articles, the results showed that 64% of articles had a positive and insignificant effect, 8% of articles had a negative and significant effect, and 28% articles have a significant and positive effect. Then, Kweon et al. (2017) found that schools with more trees had a higher percentage of proficient or advanced scores in Mathematics and Reading standardized tests. Students' perception of *Green Space* did significantly affect their achievement. Students in green schools are glad to study, and their positive mood improves their understanding when studying in the classroom. Furthermore, Beere and Kingham (2017) and Browning et al. (2018) also found a negative effect of *Green Space* on Academic Performance. These researchers found a significant negative relationship between greenness and test scores. It differs from the previous study; the test scores decrease when the environment is greener. It is supposed that students get too relaxed while studying. Related to the implementation of *Green Space*, various universities in Indonesia nowadays have begun developing various pro-environmental programs; moreover, green metric measurements will give a positive image if they reach the initial rank. This image will be beneficial for the university itself and the academics (Green Metric UI 2019).

Universitas Negeri Semarang (UNNES) is one of the universities implementing environmental pro-environmental. UNNES is an appropriate research object because the green environment is evenly distributed in all campus areas; pro-environmental courses are included in the university curriculum. Various greening programs involve all academics. It indicates that the UNNES is seriously implementing the vision of pro-environmental-oriented or pro-environmental programs. The previous inconsistent results encouraged the researchers to analyze whether the *Green Space* perceived by students can improve their Academic Performance. Furthermore, research on students' pro-environmental behavior has also been carried out by many researchers at UNNES. First, Rahmaningtyas et al. (2018) found that 89% of UNNES students have demonstrated pro-environmental behavior, and 11% still throw garbage carelessly and smoke in campus areas. Then, Rahmawati et al. (2020) found that simultaneously, the knowledge of students (X1) and students' perception (X2) have significant effects on 66.5% of their attitudes on environmental pro-environmental (Y). Third, Naim et al. (2020) found that pro-environmental knowledge had a positive but insignificant effect on pro-environmental behavior for 10.3%, and environmental awareness had a positive and significant effect on 29.7% on pro-environmental behavior. UNNES, as a pro-environmental university, has implemented a pro-environmental program for students. The study results showed that most UNNES students have successfully displayed an environmentally friendly attitude.

This study aimed to compare the effect of students' perception of *Green Space* on their academic performance and the effect of students' perception of *Green Space* on their pro-environmental behavior.

Literature Review

Green Space

A *Green Space* is generally defined as a piece of open land accessible to the public and partially or wholly covered by grass, trees, or other plants (The United States Environmental Protection Agency, 2014). It is the one and only independent variable of this study. It has been reported that students know and feel well about the green atmosphere at the UNNES campus since they spend much time studying social interactions and other activities. What has yet to be reported is how students describe and can inform the researchers about what they perceive on *Green Space* at UNNES Campus.

The better the quality of the green environment comfortable humans feel. It is in line with the fact that learning outside the classroom with a green view can help understand and retain learning (Fägerstam & Blom, 2012). Classrooms with windows with green views can increase concentration and reduce stress and stress levels compared to classrooms without green views (Li & Sullivan, 2016). McGarigal (2012) mentions *Green Space* indicators, including (a) the total *Green Space* area related to the population and urban context, (b) the quality of *Green Space* based on the size, shape, and cover of vegetation, and (c) the spatial distribution and accessibility of *Green Space*. Verma et al. (2020) also mentioned that the indicators of *Green Space* included three categories of socioeconomic, demographic, and land use for microscale population groups.

Green Space is a variable that needs to be measured together with academic performance and pro-environmental behavior variables. Two variables, *Green Space* and pro-environmental behavior are measured using the indicator approach. We made statements for each indicator to be compiled into a questionnaire. The indicator approach is used to help measure the changes that occur, either directly or indirectly.

The questionnaire is the tool for data collection, and students, as the respondents, need to fill in the questionnaire about *Green Space*. Based on their perception, they need to describe and inform *Green Space* at UNNES Campus. Segal (1971) stated that perception is an experience that occurs in response to a physical stimulus.

The indicators of perception based on Walgito (2010) are:

1) Absorption of stimuli or objects from outside the individual

The five senses absorb or receive stimuli or objects. From the results of absorption or acceptance by the senses, the individual will get a picture, response, or impression in the brain. The image can be singular or plural, depending on the object of perception being observed. In the brain, images or impressions, both old and newly formed, are collected. Whether or not the picture is clear depends on whether or not the stimulus is apparent, the normality of the senses, and time, just or a long time ago.

2) Understanding

After the images or impressions occur in the brain, the images are organized, classified (classified), compared, and interpreted to form an understanding. The process of understanding is unique. The formed understanding also depends on the old images that the individual has previously recalled.

3) Assessment or evaluation

After an understanding is formed, the individual's understanding is assessed. Individuals compare the newly acquired understanding with the criteria or norms that the individual has subjectively. Individual judgments vary even though the object is the same. Therefore, perception is individual.

Academic Performance

The first dependent variable is Academic Performance (Y1). According to Suryabrata (2006), academic performance is an assessment of educational outcomes to determine how far the students' abilities are after learning and practicing. According to Bloom (Hipjillah & Badriyah, 2015), academic achievement is a process experienced by students to produce changes in knowledge, understanding, application, analytical power, synthesis, and evaluation. Narad and Abdullah (2016) defined Academic Performance as an educational goal achieved by a student, teacher, or institution during a specific period and measured by examinations or continuous assessment. The objectives may differ from one individual or institution to another.

Academic performance can be measured and observed in scores obtained by students in assessments such as class exercises, class exams, midterms, and end-of-semester exams (Yusuf et al., 2016). One tool to measure Academic Performance is Grade Point Average (GPA) (Center for Research and Development Academic Performance CRIRES, 2005). GPA is the average result of all grades. GPA is an accumulation of scores in different subjects obtained during the learning process; it is an ideal measure that reflects Academic Performance and determines the number of courses that will be taken for the next semester. One measure of the success of these students can be seen from the scores obtained.

Pro-environmental Behavior

The second dependent variable is Pro-Environmental Behavior (Y2). Lee (2011) believes that pro-environmental behavior is a practice that promotes resource protection and pro-environmental practices and supports the sustainable use of the natural environment. Pro-environment is actioned by individuals or groups that promote or produce sustainable use of natural resources (Sivek & Hungerford, 1989/1990). Furthermore, Lee (2011) believes that pro-environment behavior is a practice that promotes the protection of resources and pro-environmental practices support the sustainable use of the natural environment.

Related to pro-environmental behavior, Mesmer-Magnus et al. (2012) defined that individual behavior contributes to environmental sustainability (such as limiting energy consumption, avoiding waste, recycling, and environmental activism). Pro-environmental behavior refers to general environmental behavior, such as initiatives to understand relevant information from ecological civilizations, participation in ecological civilization activities, turning off lights when not in use, and paying attention to waste classification.

Pro-environment behavior is closely related to the Goal Framing Theory developed by Lindenberg and Steg (2013), which bases the theory on human perceptions, thoughts, and decisions organized in a modular manner. This theory focuses on overall objectives, i.e., hedonic gain and normative goals. In connection with this research, the theory confirms that normative goals can improve pro-environmental behavior.

The indicators of pro-environmental behavior by Hardati et al. (2015) include (1) Pro-environmental behavior of biodiversity pillars, (2) Pro-environmental behavior of clean energy pillars, (3) Pro-environmental behavior of green architecture pillars and internal transportation, (4) Pro-environmental behavior of paperless policy pillars, (5) Pro-environmental behavior of waste management pillars, (6) Pro-environmental behavior of arts and cultural ethics pillars, (7) Pro-environmental behavior of pro-environmental cadres pillars.

Haryati et al.'s indicators are used since the indicators were already adopted and implemented at UNNES, the research location.

Hypotheses Development

The Effect of Perception of Green Space on Academic Performance

Hodson and Sander's (2017) research indicates a positive and significant relationship between *Green Space* and Academic Performance. The results explained that the presence of a green environment could support students' academic success. It fits with the research results by Browning and Rigolon (2019), which stated that there was a relationship between *Green Space* and academic performance. They found that *Green Space* can encourage academic performance. There is a positive and significant effect of 28%, measuring the type of *Green Space* and the distance of *Green Space* around the school. Better students' perception of *Green Space* will support the quality of learning and the achievement of higher learning outcomes.

Based on the explanation and previous studies, the first hypothesis was:

H1: Students' Perception of Green Space has a positive and significant effect on Academic Performance

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STEAM Eğitimi Araştırmaları Derneği

The Effect of Perception of Green Space on Pro-environmental Behavior

In some studies, the perception variable predicts pro-environmental behavior (Gifford & Nilsson, 2014). The stronger the individual's perception, the higher his/her pro-environmental behavior will be. However, research shows that the direct relationship between perceptions, especially related to risk and pro-environmental behavior, is usually weak (Bubeck et al., 2012). Some studies have focused on how exposure to nature positively affects human well-being. Based on previous studies, the second hypothesis was:

H2: Students' Perception of Green Space has a positive and significant effect on Pro-environmental behavior.

Here is the research model of this study; see Figure 1.

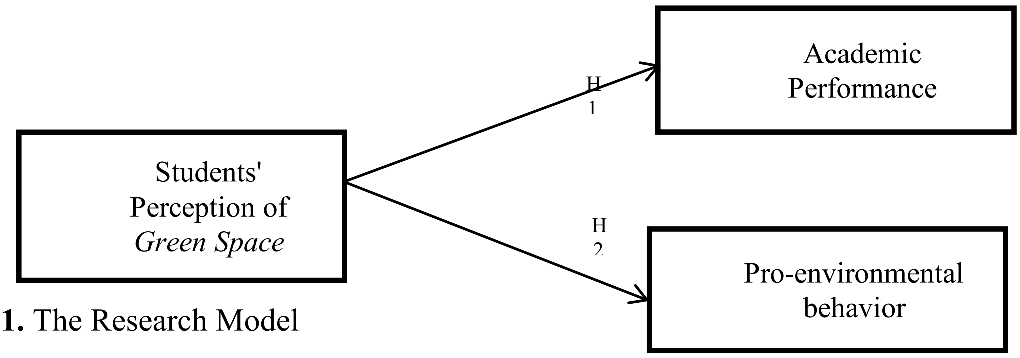

Figure 1. The Research Model

Methods

Population and Samples

The type of research used was quantitative research with a hypothesis-testing study design which aims to analyze, describe, and obtain empirical evidence of the influence pattern between variables (Wahyudin, 2015, p. 110). The data analysis method was carried out using SPSS Version 21. The total population in this study was 720 (all sixth and eighth semesters) students of the Economics Education, UNNES in 2022, and the researcher determined the error correlation range of 5%. Hence, the number of samples was 256 samples—the respondents filled in the questionnaires voluntarily and were glad to fill in since it was not tiring.

Research Instrument

Data were collected by distributing questionnaires. The questionnaire was made based on references processed by the researchers. It was distributed through *Google form* using a *Likert* scale (1 – 4 points in which 1-strongly disagree, 2-disagree, 3-agree, and 4-strongly agree) to measure the high or low conditions of indicators per research variable. We distributed the questionnaire in May 2022. The *Likert* scale was used because respondents were presented with various possible answers. *Likert* scales capture the level of agreement or their feelings regarding the topic more nuancedly. Respondents should know the situation and condition of the UNNES campus, so they should be senior students (6^{th} and 8^{th}-semester students). The data analysis method was carried out using SPSS Version 21. The definition and indicators of the research instrument can be seen in Table 1.

Table 1. Research Measurement

No.	Variables	The Operational Definition	Indicators/Measurement
1.	Perception of *Green Space*	*Green Space* is generally defined as open land accessible to the public and partially or wholly covered by grass, trees, or other plants (the United States Environmental Protection Agency, 2014). Perception is defined as an experience that occurs in response to a physical stimulus (Segal, 1971)	(1) Absorption of stimuli from outside the individual on *Green Space* (2) Understanding of *Green Space* (3) Assessment or evaluation of *Green Space* (Walgito, 2010)
2.	Academic Performance	Academic performance is defined as an assessment of educational outcomes to find out at the time of the evaluation how far the students' abilities are after learning and practicing. (Suryabrata, 2006)	Grade Point Average (GPA)
3.	Pro-environmental Behavior	Pro-environment behavior is a practice that promotes the protection of resources, and pro-environmental practices support the sustainable use of the natural environment. (Lee, 2011).	(1) pro-environmental behavior of biodiversity, (2) Pro-environmental behavior of clean energy, (3) Pro-environmental behavior of green architecture and internal transportation, (4) Pro-environmental behavior of paperless policy, (5) Pro-environmental behavior of waste management, (6) Pro-environmental behavior of arts and cultural ethics, (7) Pro-environmental behavior of pro-environmental cadres.

Source: The processed data, 2022

The dependent variables were students' academic performance and pro-environmental behavior, whereas the independent variable was Students' Perception of *Green Space*.

The validity and reliability were analyzed with SPSS Version 21. A statistic is valid if the significance level is smaller than the tolerance limit of 0.05 significance (Wahyudin, 2015). Based on SPSS calculation results, the significance value of each item was <0.05; all instruments' statements were valid. The reliability test is used to measure the consistency of a measuring instrument in measuring a concept or the consistency of respondents in answering question items in a questionnaire or research instrument; a questionnaire's statement is reliable if Cronbach's alpha values > 0.60 (Wahyudin, 2015). The counted Cronbach's Alpha was 0.812 for students' perception of *Green Space* and 0.751 for Pro-environmental Behavior. Based on these results, the statements were reliable. The validity and reliability of 2 (two) variables, pro-environmental behavior and perceptions of *Green Space*, can be seen in Table 2. The first dependent variable, academic performance, was not tested for validity and reliability since it is the manifest variable.

Table 2. Instrument's Validity and Reliability

No	Indicators	Statement	Validity	Reli.
A.	**Pro-Environmental Behavior (Y2)**			
1.	(1) pro-environmental behavior of biodiversity	I like the green campus atmosphere	0.000	0.954
2.		I like to hear animal sounds, such as birds chirping, cats meowing, and others	0.000	
3.		I like the calm and healthy campus air	0.000	
4.		I am happy to see the flowers in the faculty yard	0.000	
5.	(2) Pro-environmental behavior of clean energy,	I turn off the lights in class when it is not in use	0.004	
6.		I like to use a fan instead of an AC	0.025	
7.		I like to take public transportation or walk	0.000	
8.		I will turn off the laptop when it is not in use or in hibernate state	0.000	
9.	(3) Pro-environmental behavior of green architecture and internal transportation,	I use a vehicle with complete components (helmets, mirrors, etc.)	0.000	
10.		I like to greet campus residents	0.000	
11.		I use my motorbike at an average speed on and off campus	0.000	
12.		I use enough water (as needed)	0.000	
13.	(4) Pro-environmental behavior of paperless policy	I reuse old paper for other purposes	0.000	
14.		I try to reduce the use of printed paper	0.000	
15.		I proofread carefully before printing the script	0.000	
16.		I will only print scripts that are used	0.000	
17.	(5) Pro-environmental behavior of waste management	I throw garbage in its place (organic and inorganic)	0.000	
18.		I pick up trash that is around me (inorganic)	0.009	
19.		I try to bring my place or container when shopping	0.000	
20.		I am happy to participate in environmental clean-up work	0.001	
21.	(6) Pro-environmental behavior of arts and cultural ethics,	I like to buy domestic products (clothing and goods)	0.000	
22.		I enjoy watching traditional art performances such as *Wayang/ Traditional Javanese Puppets.*	0.033	
23.		I like wearing batik clothes	0.000	
24.		I like to eat traditional food	0.000	
25.	(7) Pro-environmental behavior of pro-environmental cadres.	I enjoy participating in social service activities in student organizations	0.000	
26.		I participate in unit conservation cadre activities	0.018	
27.		I enjoy attending seminars on conservation	0.000	
28.		I enjoy doing conservation skills training	0.000	
B		**Perceptions of Green Space**		
No	**Indicators**	**Statement**	**Validity**	**Reli.**
1.	(1) Absorption of stimuli from outside the individual on *Green Space*	I feel happy because of the broad and large number of *Green Space*s on the UNNES Campus	0.000	0.939
2.		I know that the UNNES Campus has committed to providing *Green Space.*	0.000	
3.	(2) Understanding of *Green Space*	I understand that UNNES is committed to providing *Green Space* for its academic community.	0.000	
4.		I understand that *Green Space* is maintained on the UNNES Campus and is supported by its conservation policy	0.000	
5.	(3) Assessment or evaluation of *Green Space*	I think UNNES is a green campus with excellent *Green Space.*	0.000	
6.		I consider that the *Green Space* on the UNNES Campus is more than sufficient because of the many parks and campus forests evenly distributed in the UNNES environment.	0.000	

After the data had been tested for validity and reliability, the data were analyzed with classic assumptions tests. Then, to test hypothesis 1 and hypothesis 2, a simple regression test with SPSS Version 2 was carried out. Regression analysis was performed to test the effect of X on Y1 and X on Y2.

RESULTS

The Effects of Students' Perception of Green Space on (X) on Students' Academic Performance (Y1)

The data from 256 students were tabulated and analyzed using a simple regression test, and the following is the regression output, as listed in Table 3.

Table 3. The Output of Linear Regression of X on Y1

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	88.160	3.859		22.845	.000
	Perception of *Green Space*	.054	.101	.030	.533	.594
a. Dependent Variable: Academic Performance						

The data above shows the independent and dependent variables' effects. In the Perception of *Green Space* (X_1) variable, the value of the t-count was 0.533, and the obtained sig-value was 0.594, which is more significant than 0.05. It means that the perception of *Green Space* positively affected academic performance, but it is insignificant. Here is the simple linear regression equation:

Y (AP) = 88.160 + 0.054 PGS + e

From this equation, it can be interpreted that an increase follows one increase in the unit of perception on *Green Space* in Academic Performance for 0.054. It is a positive effect, and since the significance is more than 0.05, it is insignificant. Next, to find out the total percentage of the effect of X on Y1; then the R2 test and the results are shown in Table 4.

Table 4. The Output of the R2 Test

Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.030[a]	.001	-.002	7.68557
a. Predictors: (Constant), Perception of *Green Space*				
b. Dependent Variable: Academic Performance				

The data above shows that the contribution of Perception to *Green Space* can be known from the value of R-Square; it is only 0.001. It means that the Perception of *Green Space* can affect the Academic Performance dependent variable with a minimal value; it was 0.1%, whereas; other factors outside the model affected 99.9% of students' achievement.

The Effects of Students' Perception of Green Space on (X) on Students' Pro-Environmental Behavior (Y2)

The data were from 256 students, tabulated and analyzed using a simple regression test, and the following is the regression output as listed in Table 5.

Table 5. The Output of Regression Analysis X on Y2

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	31.062	5.062		6.136	.000
	Perception of *Green Space*	2.746	.133	.763	20.722	.000

a. Dependent Variable: Pro-environmental Behavior

The data above partially shows the effect of the independent on the dependent variable. In the Perception of *Green Space* (X_1) variable, the count value was 20.722, and sig. 0.000 was smaller than 0.05. It means a positive and significant effect on the Perception of *Green Space* on Pro-environmental Behavior. Here is the linear regression equation:

Y (PB) = 31.062 + 2.746 PGS + e

From this equation, it can be interpreted that every increase in one unit of perception of *Green Space* is followed by an increase in Pro-environmental Behavior for 2.746. Next, to find out the percentage of the effect of X on Y1; then the R2 test and the results are shown in Table 6.

Table 6. The Output of R2 Test X on Y2

Model Summary

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.763[a]	.582	.580	10.08174

a. Predictors: (Constant), Perception of *Green Space*

b. Dependent Variable: Pro-environmental Behavior

The data above shows the contribution of the Perception of *Green Space*; from the R-Square value of 0.582. It means that the Perception of *Green Space* can affect the dependent variable Pro-environmental Behavior, by 58.2%. Furthermore, 41.8% are affected by other factors outside the model.

DISCUSSION AND CONCLUSIONS

Students' perception of *Green Space* did insignificantly affect their achievement. It was different from our initial hypothesis, which stated that the perception of *Green Space* has a positive and significant effect. The campus is a fun place to study and can generate interest in student learning, but the effect is minimal and insignificant. Faculty of Economics (FE) UNNES has equipped the campus environment with various facilities to support students' learning. One of them is making a park around the campus area. The campus park can present a beautiful and relaxed campus environment so students feel comfortable and excited to study. Students can study, read books, and have discussions in the campus park. *Green Space*s such as green fields, trees, and plants are expected to provide a level of comfort for students to carry out activities such as studying. The study, which shows that students' perception of *Green Space* did insignificantly affect their achievement, is not surprising because Beere and Kingham (2017) found a negative effect of *Green Space* on Academic Performance. It was consistent with the study results done by Browning (2018). He found only a significant negative relationship between greenness and test scores. However, the coefficients were near zero or less than a tenth percentage point. It is in line with Markevych et al. (2018), which found that there was not any relationship between *Green Space* and grades in Wesel's children (The population of Markeyych et al.'s research). However, academic performance is more affected by other factors, such as internal motivation, lecturers, friends, and family factors on students' academic performance. Olufemi et al. (2018) also showed that academic performance is influenced by students' factors, parental background, and school factors. Then, Bertolini et al. (2012) stated that several factors impact Academic Performance, such as students' factors and their interactions with parents, teachers, and administrators. The larger systems are surrounding the student impact students' achievement, e.g., school districts, neighborhoods, local economy, political policy, and multicultural relations. Therefore, *Green Space* becomes an insignificant variable on Academic Performance despite its positive effect. The students, lecturers, peers, and parents are the variables that are supposed to have a significant effect. Here, pro-environmental behavior includes energy saving, less paper, waste utilization, and reforestation. Dense student learning activities and limited time to refresh their thoughts cause a higher risk of stress. The existence of *Green Space*s around the campus can reduce stress and improve both physical and mental health. It also has an impact on students' pro-environmental behavior.

Furthermore, the perception of *Green Space* (X) positively and significantly affects pro-environmental behavior (Y2). It can be seen from the X coefficient was 2.746 with a sig value count was 0.000. It was consistent with the study result of Shamsuddin et al. (2012), which found that some relationships exist between the outdoor physical environment of the school and the student's social behavior. The design and planning of the school's external environment should give more consideration to creating a conducive learning environment that could foster positive social behavior. It is consistent with the second hypothesis that *Green Space* can improve student pro-environmental behavior. *Green Space*s such as green fields, trees, and plants can comfort students, thereby increasing their awareness of the importance of *Green Space*s. Humans tend to like green and cool things and become an inspiration to do the same and be conservative regarding green and cool things. It is also related to a study by Whitburn et al. (2018), which reported that pro-environmental behaviors (PEBs) are associated with a personal relationship with nature. It was also consistent with the research by Zhang et al. (2019). They stated that outdoor education programs are promoted to enhance connections between individuals and nature to foster pro-environmental behavior. From these explanations, it can be concluded that: 1) Students' perception of *Green Space* (X) has a positive but insignificant effect on Academic Performance(Y1) for 0.1% with a coefficient was 0.05; on the other hand; and 2) Students' perception on *Green Space* (X) has a positive and significant effect on pro-environmental behavior (Y2) for 76.3% with the coefficient was 2.74.

Recommendations

Therefore, it is recommended that: 1) Educational institutions be concerned with *Green Space* and pay attention to other factors such as the needs and rights of students in the learning process, improvement of lecturer competence, and other factors for increasing academic performance achievement. Furthermore, 2) Students to improve their pro-environmental behavior by practicing those six indicators of pro-environmental behavior; i.e., (1) biodiversity, (2) clean energy, (3) green architecture and internal transportation, (4) paperless policy, (5) waste management, (6) arts and cultural ethics, and (7) behavior of pro-environmental cadres.

The Limitations of the Research

This research was only conducted at the Faculty of Economics, *Universitas Negeri Semarang (UNNES)*, one of the faculties with good pro-environmental commitments. It would undoubtedly be different if the research were carried out in different spaces. This study only uses indicators from variables adjusted to UNNES conditions. Research results may differ if other indicators are used.

DECLARATIONS

Authors Contributions: All authors contributed equally to the work.

Ethics: The research was conducted in accordance with the Universitas Negeri Semarang code of ethics.

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