Eurasian Journal of Educational Research 98 (2022) 21-37

Eurasian Journal of Educational Research
www.ejer.com.tr

An Experiment in Applying Differentiated Instruction in STEAM Disciplines

Altangerel Balgan[1], Tsolmon Renchin[2], Khulan Ojgoosh[3]

ARTICLE INFO

Article History:

Received: 15 October 2021

Received in revised form: 13 December 2021

Accepted: 20 February 2022

DOI: 10.14689/ejer.2022.98.02

Keywords

Multiple Learning style, Achievement, Modification teaching approach.

ABSTRACT

Purpose: Science Technology Engineering Mathematics (STEM) is developing now in Mongolian Universities. Research in STEM education is increasing in importance globally and is an international field. Less information is available concerning the relationships among behavior, multiple intelligence, and learning style of differentiated instruction for the STEM classroom. There is a need for a teaching methodology on how to deliver STEM contents to every student in Mongolia. **Method:** This study developed a differentiated teaching approach based on nine multiple intelligence and learning style differences. To create the teaching approach, first, the study had the Gardner test and Visual, Authority, Kinesthetic (VAK) behavior test among 76 students. **Findings:** This study found a proper modification teaching approach for the intelligent ability and learning styles. **Implications for Research and Practice:** After implementation of the modification, the academic achievement and engagement of the students increased by 9.3 percent. The study findings reveal correlations between VAK, Intelligence ability, and temperaments of the students. These relationships can be used for teaching STEM and preparation classes.

© 2022 Ani Publishing Ltd. All rights reserved.

[1] National University of Mongolia, Email: altangerel.b@num.edu.mn
[2] National University of Mongolia, Email: tsolmon@num.edu.mn
[3] National Educational University of Mongolia, Email: khulan.o@msue.edu.mn

Introduction

STEM Education was originally used for Science, Mathematics, Engineering, and Technology (SMET) (Sanders, 2009) and was an initiative created by the National Science Foundation (NSF). This educational initiative provided all students with critical thinking skills that would make them creative problem solvers and ultimately more marketable as the workforce (White, 2014). The advantage of attending STEM Education if they did attend college, particularly in a STEM field, was very significant. However, when later Arts was added, it came to be known as STEAM, for Science, Technology, Engineering, Arta and Mathematics.

Each of the components of STEM plays an essential role in the modern society. *Science*: it is the systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms (Hochella Jr et al., 2019). *Technology*: it is the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science (De Vore, 1992). *Engineering*: refers to the art or science of making practical application of the knowledge of pure sciences, such as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants (White, 2014). *Mathematics*: it is a group of related sciences, including algebra, geometry, and calculus, concerned with studying numbers, quantity, shape, and space and their interrelationships by using a specialized notation (Tezer & Karasel, 2010).

LaForce et al. (2017); Lee et al. (2019) indicate that STEM education has the potential to motivate students to study and participate in STEM fields for their future careers. According to a few other studies (Al Salami et al., 2017; Asghar et al., 2012; Bagiati & Evangelou, 2015; Lee et al., 2019; Margot & Kettler, 2019), STEM education has been the part of curriculum in many educational systems in many countries, such as the United States, Australia, and other Western countries. Studies report that teachers face many problems in STEM education, particularly in developing countries of Asia (Lee et al., 2019; Margot & Kettler, 2019; Ryu et al., 2019). However, there is a strong link between the quality of the learning process and STEM education outcomes in Asian countries (Khaeroningtyas et al., 2016; Yıldırım & Sevi, 2016). Specifically indicate the importance of engineering design as an emerging area of research.

STEM education is the teaching method, whose class activities have great importance for making subjects more understandable and tangible for students (Erickson, 2010). There is also a noticeable gap in teachers' preparation and professional development (Al Salami et al., 2017; Cavlazoglu & Stuessy, 2017). Chai et al. (2020) suggest that developing epistemic fluency for fruitful interdisciplinary collaboration in pedagogical design work will require substantial time and effort. Some studies have stated that the learning process and learning outcomes might differ on many factors, such as the subject of study, learning duration, or even kinds of environmental conditions (Marton, 1996).

A differentiated teaching approach is therefore required that would account for personal differences and students' different skills and learning needs (Al Salami et al., 2017; C. A. Tomlinson, 1999; J. W. Tomlinson et al., 2001). King-Shaver (2008) defines differentiated

instruction as a deliberate and conscious method of planning and teaching that provides multiple avenues of learning toward clearly defined goals. C. A. Tomlinson (1999) states that the differentiated teaching approach involves multiple intelligence and thinking styles, while Levy (2008) defines differentiated teaching approach as a learning experience in which various strategies are used to introduce students to the content of the program and activities. Goodpaster et al. (2012) calls differentiated teaching as an educational approach that will compensate for students' requirements by increasing their learning and motivation. Differentiated teaching offers various methods based on the instructor's teaching profile, skills, interests, pre-knowledge, and students' learning styles (Cassady et al., 2004).

Differentiated instruction is widely known as a method of teaching that meets the diverse needs of students. Algozzine and Anderson (2007) noted that teachers must provide a differentiated learning environment, particularly for those children who lack sufficient knowledge and skills in any subject (Richards & Omdal, 2007). Lauria (2010) concluded that educators have the most significant potential to make successful students by using differentiated instruction. Evans and Waring (2011) argued that differentiated instruction allowed the educators to understand the strengths and needs of all students in their classrooms. However, little information is available concerning teachers' actual execution of differentiated instruction in the classroom. Davis and Petretic-Jackson (2000) noted that classes should include students of diverse needs, achievement levels, interests, and learning styles, and instruction should be differentiated to take advantage of the diversity, not to ignore it.

It has been observed that by encouraging STEM education in developing countries, many new jobs have been created in fields like medicine, computer, and IT. Educating people in these fields has brought tremendous growth in the economy of the respective nation and helped people get out of poverty. Robotic camps have popped up worldwide, not just in the developing countries, which have increased children's interest in STEM fields through fun with learning activities. In addition, more and more women are also joining the STEM fields and breaking down some common gender barriers. STEM education is becoming more focused as our world becomes ever more digital. Bruce-Davis et al. (2014); Dare et al. (2014); Goodpaster et al. (2012); Van Haneghan et al. (2015) noted how teachers used kinesthetic activities to motivate their students. Asghar et al. (2012) find out that teachers felt the engineering-based hands-on activities would be beneficial as students master math concepts. With the beautiful encouragement that learners in developing parts of the world have received, STEM education and the respective fields should continue improving (DeBoer, 2000).

There is no dearth of research on teaching and learning process in the STEM fields for their class enactment (Lee et al., 2019; Li et al., 2019; Lou et al., 2017; Yildirim, 2016; Yildirim & Altun, 2015; Yıldırım & Sevi, 2016). These studies focus on the academic learning achievement in the STEM-related subjects. These studies have also noted that research in STEM fields has increased globally and internationally (LaForce et al., 2017; Li et al., 2019; Li et al., 2020). A few researchers even developed a teaching model with a learning approach for STEM implementation (Suratno et al., 2020), while others have focused on the importance of STEM education. These researchers reveal that learning outcomes are a result of the learning process.

Learning outcomes are the main target in a learning process, including STEM enactment. Some researchers argue that students' learning outcomes are all types of results expected during and after the learning process (Cassady et al., 2004). Elfrink et al. (2010) indicate that learning outcome is a teaching result expected to be obtained by students after the completion of a learning process. Learning outcomes are usually expressed in knowledge, skills, and attitude. Havnes and Prøitz (2016) describe that there is no precise way of defining or writing the meaning of such learning outcomes, but a learning outcome must be measurable. Moreover, learning outcomes can be in various forms, depending on the purpose expected by a teacher.

Asian and Western countries may have many differences in teaching and learning characteristics as well as in their culture; however, both regions have similarities primarily in terms of problems and challenges faced in the education field. The development of STEM education in the west was motivated by the low interest of the younger generation in work related to the STEM field. This low-interest condition was also exacerbated by the increasing competitiveness of the workplace and uncertain global world challenges (Cavlazoglu & Stuessy, 2017). Several research studies on STEM fields have outlined the significance of differentiated teaching for attaining the required learning outcomes in developing countries (Di, 2017; Hassan & Jamaludin, 2010; Lee et al., 2019).

For this reason, STEM has become more vital in developing countries of Asia like Mongolia, the research setting of the current study. The universities in Mongolia are not an exception but there is a need to teach methodology on how to deliver STEM contents to every student in Mongolia. It is essential that teachers use differentiated teaching to meet the diverse needs of students and to meet the challenges of teaching STEM subjects. However, little information is available concerning the relationships among behavior, multiple intelligence, and learning style of differentiated instruction for the STEM classroom.

According to Erickson (2010), STEM education needs a teaching method and strategy that should make subjects more understandable and tangible for students. The teaching should be carried out with such class activities that help attaining student-learning outcomes. By adopting the differentiated teaching approach, a change is seen in academic achievements that indicate the extent to which students have achieved their learning goals. The current study therefore focused on developing differentiated teaching methods based on students' learning style, behavior, and capacity to learn multiple intelligence abilities to attain the desired learning outcomes.

Theoretical Framework

In this paper, academic achievement was measured through students' grade points. To apply differentiated instruction appropriately, it was essential to know students well. Howard Gardner's tests (http://epltt.coe.uga.edu/index.php) was used to investigate students' intelligence abilities, results of which are presented in Figure 1. The tests contained questionnaires for eight different intellectual abilities, namely verbal-linguistics, logical-mathematical, musical, visual-spatial, bodily-kinesthetic, intrapersonal, interpersonal, and naturalistic. These multiple intelligences were rated among 76 students, the highest percentage recorded was in intrapersonal at 29 percent and the lowest was recorded in the

musical domain at 3 percent. Other significant abilities included logical-mathematical, visual-spatial and interpersonal at 14, 18 and 21 percent respectively for selected students. These results show that students studying STEM subjects acquire its learning in different ways.

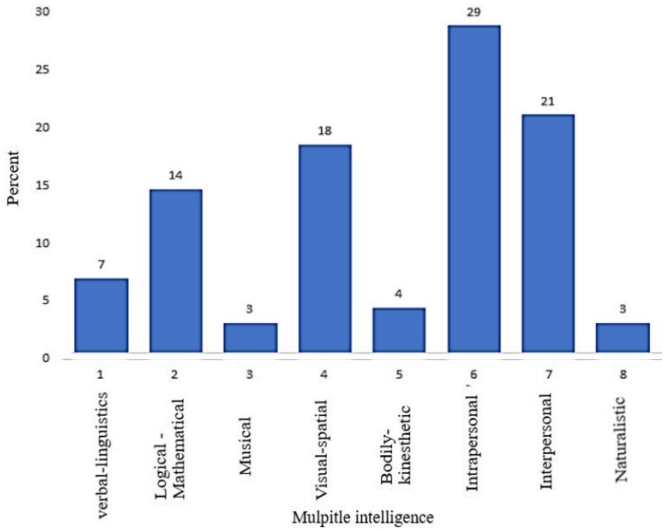

Figure 1. *Multiple intelligence ability for 76 students*

Figure 2 is evident of five students sampled for this study, each of same age but seen with different dominant intelligent abilities. For instance, student 1 has interpersonal intelligence; student 2 has musical, student 3 has visual-spatial, student 4 has musical and interpersonal, and student 5 has verbal-linguistics, visual-spatial, intrapersonal, and interpersonal. This result suggests that one student can have more than one intelligence ability.

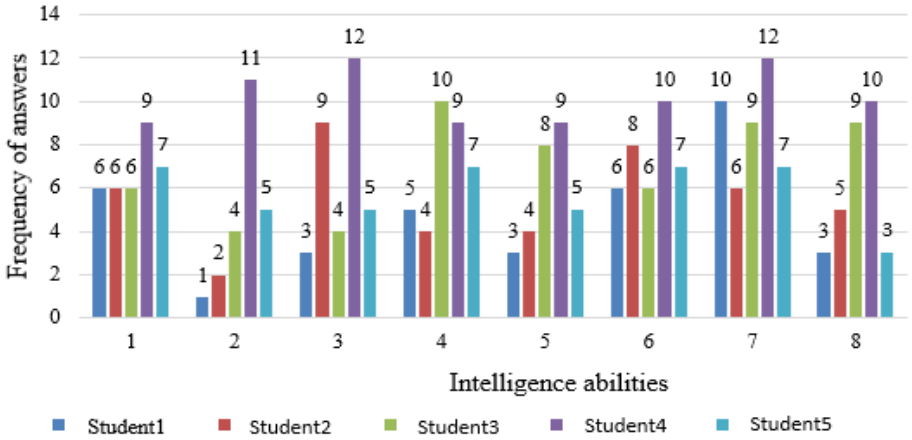

Figure 2. *Comparison of student's intelligences ability*

Likewise, in order to identify students' personality types, strengths, and preferences. the Myers-Briggs Personality Type Indicator Test was designed for this study. This test uses the Visual-Auditory-Kinesthetic learning styles (VAK) model to classify students' learning styles. The Visual-Auditory- Kinesthetic learning styles model was first proposed by psychologists like Fernald, Keller, Orton, Gillingham, Stillman, and Montessori in 1920s.

The test classified people's learning styles into three categories based on the modalities people learn—VAK stands for Visual, Auditory, and Kinesthetic (Tactile). According to the VAK model, most people possess a dominant or preferred learning style, which means that students can learn most effectively through one of these channels, while some have combined learning styles. Some students are visual learners, while others are auditory or kinesthetic learners. Visual learners learn visually through pictures. Auditory learners learn by listening to teachers. Kinesthetic learners learn by moving or doing. Figure 3 illustrates that 28%, 33% and 39% of students learned through Visual, Auditory, and Kinesthetic channels respectively.

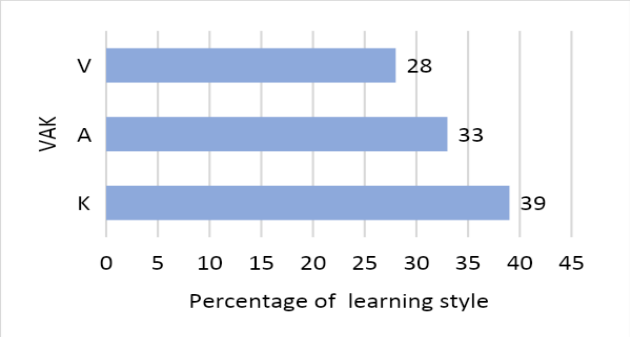

Figure 3. *Personality type for the selected students*

Finally, Myers-Briggs Personality Type Indicator test was designed to identify students' personality types, strengths, and preferences for this research. Accordingly, Figure 4 presents the classification of behavior of students as 40% choleric, 30% melancholic, 20% phlegmatic, and 10% sanguine.

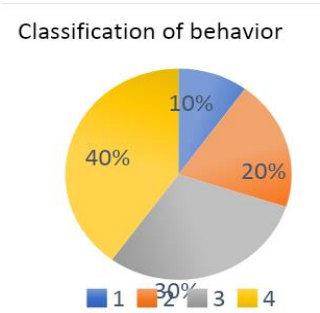

Figure 4. *Learning style differences for the students*

Figures 1-4 show different intellectual abilities, learning styles, and personality and behavior types of students. These figures formulate the theoretical framework of this study to first develop a differentiated teaching approach for STEM education and then devise such teaching models that help achieve learning outcomes.

Method

- *Research Design*

Since this study focused on what is essential in the learning for the students with different intelligence skills, a modification approach was proposed. The research design was based on Gardner's eight multiple intelligence skills to select modification activity. Gardner's eight multiple intelligence skills were presented as an action oriented model wherein the teacher centered and learner- centered activities took place. Figure 5 presents the plan-organize-lead-monitor as external activities, while effort-earning-activity-engagement are seen as internal activities. These activities were both goal and result oriented where motivation was a major factor to take action.

Figure 5. *Modification approach for differentiated teaching*

- *Research sample*

The sample of the study comprised 76 selected university students. These students were selected from the STEM classes in a Mongolian University.

- *Research Instruments and Procedure*

The modification approach used in this study (Figure 5) was required to apply on differentiated instruction teaching. This proposed method consisted of planning activities, organizing engagement, leading efforts, and monitoring earnings. Right at the outset, an activity in STEM class was planned. To reach the goal, the teacher organized engagement and lead efforts while monitoring the learning process. After application modification, approach engagement in the class improved. We examined student engagement and academic achievement in each STEM class. Student engagement was evident when students showed up to class and were excited to learn and demonstrated a positive attitude. This showed how academic achievement was reflected in academic outcomes that indicated how students achieved their learning goals.

- *Data analysis*

The SPSS program was used to find Pearson's correlation coefficient which is a statistical measure of the strength of the relationship between the relative movements of two variables.

Results

Academic achievement in this context referred to completing educational benchmarks such as a bachelor's degree. Academic achievement was often measured through examinations or continuous assessments. Academic achievement was how a student or institution achieved either short or long-term educational goals. Achievement can also be measured through students' grade point average, whereas achievement may be measured through graduation rates for institutions (Richards & Omdal, 2007).

The findings of the study are evident in Table 1, in accordance with Gardner's eight multiple intelligence skills to select modification activity.

Table 1

Modification Activities

Multiple intelligence skills	Activities
1. Verbal-linguistics (Word smart)	- Participate in discussions, debates and brainstorm in small group
2. Logical - Mathematical (Logic smart)	- Solve problems and solve puzzles based on logical thinking - Predict the outcome based on the situation -Statistical analysis, results analysis, conclusions and reports
3. Musical (music smart)	- Write poems and songs -Exercise while listening to music
4. Visual-spatial (Picture smart)	- Participate in artistic activities such as drawing and playing - Read and create maps - Think and reflect using pictures - Create and explain photo albums
5. Bodily-kinesthetic (Body smart)	- Think, think, and use pictures - Use basic body parts to measure things - Speak with conviction - Learn folk dances that express a unique culture - Draw using simple tools and think about your scribbler - Designing things - Moving exercises, developing and using video lessons
6. Intrapersonal (self-smart)	- Work independently - Write essays and reflections - Keep notes and journals - Work in teams
7. Interpersonal (people smart)	- Teach to other students, plan and implement mini-lessons - Organize an interview - Organize team formation, team selection, and assignment - Talk and solve problems together
8. Naturalistic (Nature smart)	- Read, classify and systematize natural objects and phenomena - Do an online search for plants and animals - About loving, protecting and caring for nature, plants and animals - Think and create useful things of loving, protecting and caring for nature, plants and animals

It was observed that after applying modification activity, engagement and academic achievement in the class increased, as evident in Table 2.

Table 2

Achievement of Engagement

			Before Modification approach		**After Modification approach**		
VAK	Gardner	N	Mean	SD	Mean	SD	Difference in scores
V	1	1	18.00	.	28.50	.	10.5
	2	5	20.00	.000	29.80	.447	9.8
	4	5	18.00	3.937	27.40	4.775	9.4
	6	7	13.57	3.359	25.93	3.168	12.36
	7	3	19.00	1.732	29.33	1.155	10.33
	Total	21	17.14	3.745	27.81	3.223	10.67
A	1	3	16.00	5.196	23.33	6.028	7.33
	3	3	15.33	4.726	21.00	3.000	5.67
	4	3	13.67	3.786	21.33	4.481	7.66
	6	4	17.75	3.862	26.38	5.186	8.63
	7	11	15.73	4.197	26.41	3.936	10.68
	Total	24	15.79	4.054	24.71	4.618	8.92
K	1	1	11.00	.	27.00	.	16
	2	6	19.17	1.602	28.67	2.160	9.5
	4	6	16.83	3.189	27.83	2.229	11
	5	3	18.67	1.155	25.33	5.686	6.66
	6	10	15.20	4.442	25.10	4.683	9.9
	7	2	14.50	4.950	19.75	8.132	5.25
	8	3	18.67	1.528	27.83	2.255	9.16
	Total	31	16.77	3.640	26.32	4.261	9.55
Total	1	5	15.40	4.506	25.10	4.930	9.7
	2	11	19.55	1.214	29.18	1.662	9.63
	3	3	15.33	4.726	21.00	3.000	5.67
	4	14	16.57	3.694	26.29	4.388	9.72
	5	3	18.67	1.155	25.33	5.686	6.66
	6	21	15.14	4.090	25.62	4.147	10.48
	7	16	16.19	3.987	26.13	4.738	9.94
	8	3	18.67	1.528	27.83	2.255	9.16

Table 2 indicates that Gardner's multiple intelligences and VAK learning styles are related to the learning process of 76 students. There are five students with linguistic ability (1) one of them has a visual learning style, three have an auditory learning style, and one has the kinesthetic learning style. Eleven learners have Logical-Mathematical ability and six of them learn by doing and touching, and action, while five of them are visual learners. There are three students with musical abilities, all of them learn by hearing. There are 14 with visual-spatial, five of whom are visual learning styles, three students are auditory learners, and six are kinesthetic learners. There are three students with a visual-spatial ability, and all of them learn through movement. The highest number of students have the intrapersonal ability who are 21.

From those who are intrapersonal, seven of them are visual, four are auditory, and ten are kinesthetic. While there are 16 students with an interpersonal ability, three students are visual, 11 students are auditory, and two are kinesthetic. There are three students with naturalistic love and protection nature, and all of them have kinesthetic learning styles. Table 2 thus reveals that intellectual ability and learning styles are interrelated. According to Table 2, the intrapersonal ability is prevalent and musical, bodily-kinesthetic and naturalistic abilities are low for the selected students. The modification approach was applied to the students with different learning styles.

From Figures 6 and 7, we found an increase in engagement and academic achievement after the modification approach by 9.3 percent. Percentage of engagement for the students for the three learning styles also improved. Engagement for V learning style students is slightly higher than for students with learning styles A and K. Active learning engages students in activities beyond reading, listening, writing, speaking, or watching to deepen their learning and connection with the STEM teaching materials. Engagement is talking with each other, developing skills, thinking, building, and constructing.

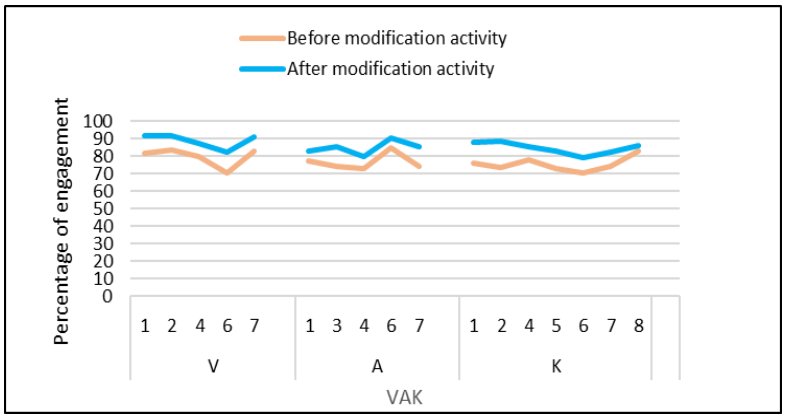

Figure 6. *Percentage of engagement change*

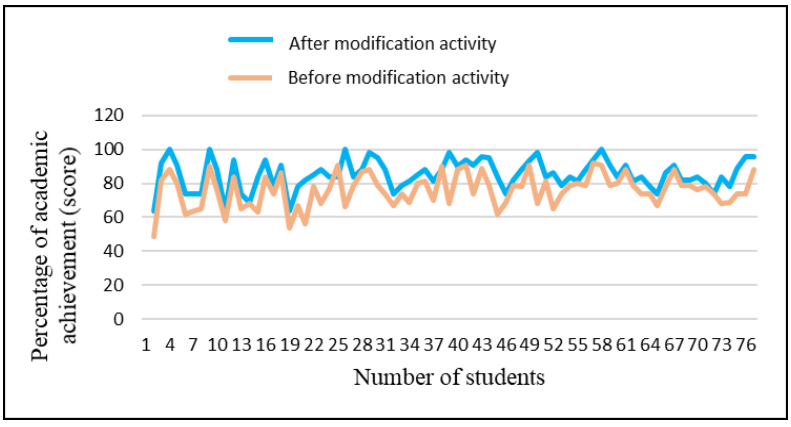

Figure 7. *Percentage of academic achievement change*

Academic achievement represents performance outcomes that indicate how a person has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college, and university. Before modification activity either apply across multiple subject areas (e.g., critical thinking) or include the acquisition of knowledge and understanding in a specific intellectual domain (e.g., numeracy, literacy, science, history).

Table 3

Correlations of learning style

Correlations

		Listening	Speaking	Reading	Writing
Listening	Pearson Correlation	1	.808**	-.047	-.014
	Sig. (2-tailed)		.000	.689	.908
	N		76	76	76
Speaking	Pearson Correlation		1	.113	.127
	Sig. (2-tailed)			.332	.274
	N			76	76
Reading	Pearson Correlation			1	.909**
	Sig. (2-tailed)				.000
	N				76
Writing	Pearson Correlation				1
	Sig. (2-tailed)				
	N				

**. Correlation is significant at the 0.01 level (2-tailed).
Note: Pearson Correlation Coefficient Calculator

The Pearson correlation coefficient measures the strength of a linear association between two variables, where the value r = 1 suggesting a perfect positive correlation and the value r = -1 means a perfect negative correlation. In the classes, it was analyzed how listening, speaking, reading, and writing correlated with each other for STEM teaching. Table 3 reveals that there is a good relationship between listening and speaking. Reading and Writing have a good agreement. This result was used for the development of the modification approach with regard to intellectual ability and VAK. After applying the modification approach and using Table 2 and Table 3 we received correlations among VAK, Intelligence ability and temperaments in Table 4. From the Figure 3, listening and speaking have 0.808 relationships, and writing and reading have 0.909 relationships.

The values of variables ranged between -1.0 and 1.0. A calculated number greater than 1.0 or less than -1.0 means an error in the correlation measurement. A correlation of -1.0 shows a perfect negative correlation, while a correlation of 1.0 shows a perfect positive correlation. For instance, for VAK visual style reading ability is high and reading has a good relationship with writing. Therefore, reading and writing must meet VISUAL style. A correlation of 0.0 shows no linear relationship between the movement of the two variables.

For example, the verbal-linguistic style has a speaking ability. However, because of the high Pearson's correlation between listening and speaking ability. So the verbal-linguistics style has speaking and listening ability. Analysis in Table 3 was used to find the correlations between the STEM skills and multiple intelligences.

Table 4

The correlations between the STEAM skills and multiple intelligences

	Learning style	Listening	Speaking	Reading	Writing
VAK	Visual			✓	✓
	Auditory	✓	✓		
	Kinesthetic			✓	✓
Gardner	Verbal-linguistics	✓	✓		
	Logical-mathematical			✓	✓
	Musical	✓	✓		
	Visual-spatial			✓	✓
	Bodily-kinesthetic			✓	✓
	Intrapersonal			✓	✓
	Interpersonal	✓	✓		
	Naturalistic			✓	✓
Temperaments	Phlegmatic			✓	✓
	Choleric	✓	✓		
	Sanguine	✓	✓		
	Melancholic			✓	✓

From Table 4, it is seen that the students with Kinesthetic and Visual are good at reading and writing while the students with Auditory are good at listening and speaking. Temperaments can also influence students' learning achievements. Choleric and Sanguine students can be good at listening and speaking, while Phlegmatic and Melancholic are good at reading and writing activities in the class.

This study analyzes learning styles prevalent by university students and examines how student-learning outcomes vary after applying the modification approach. STEM classes can include students of diverse needs, achievement levels, interests, and learning styles. Teaching should include differentiated instruction, especially in STEM classes. Engagement in class and academic achievement vary in areas, including intellectual attitude and motivation. Since STEM education is necessary and educators are facing challenges in teaching STEM. In the first line, students' achievements with V (visual) learning style and intrapersonal ability increase mainly. Auditory learners with interpersonal abilities earned high scores comparing the previous assessment. Students with Gardner's 2nd and 8th intelligence of logical math and natural abilities learn better by K (kinesthetic) learning style.

The result reveals that student engagement increases after using the modification approach concerning interrelationships of the multiple intelligences and learning styles. From the above, it can be seen that students with visual learning style and linguistic ability (1) and students with logical mathematics (2) and intrapersonal (6) abilities have the highest grades and show effectiveness. Students with a high level of interpersonal ability (7) and musical ability learn by hearing. Students with high levels of natural ability and physical ability (4) learn by movement and doing. The modification provided students at all levels with a better understanding of the STEM subjects to increase their success and motivation and to make them responsible for their learning. The approach developed in this research allowed students to reach a common goal, regardless of their path to get there.

Discussion

The purpose of this study was to analyze how academic achievement was improved after applying a modification approach. Therefore, academic achievement is considered to be different domains of learning. Because the field of academic achievement is very wide-ranging and covers a variety of educational outcomes, the definition of academic achievement depends on the indicators used to measure it.

In this study we used grade point as the academic achievement for the students of the same age. Academic achievement and engagement classes can be changed in case we involve different ages and specific groups of students. These results can be changed differently for different age groups. There also will be different challenges. Some specific groups need additional support in STEM education. It is seen that the students with Kinesthetic and Visual are good at reading and writing while the students with Auditory are good at listening and speaking. Temperaments can also influence students' learning achievements. Choleric and Sanguine students can be good at listening and speaking, while Phlegmatic and Melancholic are good at reading and writing activities in the class.

Teachers may start STEM engagement, allowing them to read and write ideas of construction and making and building as students may start to form aspirations towards a STEM career. Teachers may provide more talk and explain to the students with auditory learning styles and allow them more talk about their ideas for STEM learning. This study reveals that students' behavior influences learning achievements. Personality type is an essential part of differentiating teaching for STEM. Teachers may consider students' confidence in STEM learning. Differentiating teaching allows students to make decisions on STEM participation that can impact their future education and career.

In this study students' achievements with V (visual) learning style and intrapersonal ability increase mainly. Students with Gardner's 2nd and 8th intelligence of logical math and natural abilities learn better by K (kinesthetic) learning style. From the outputs of this study it seems that students need differentiated teaching for them. Each student has a different intelligent ability, learning style and personality type for STEM class. Before teaching STEM teachers may have tests to know better their students. STEM is not a new topic but still needs improvement for teaching and learning processes that can address the challenges faced by developing countries like Mongolia.

Conclusion

The learning process and learning outcomes might differ on the subject of study. STEM class requires all students' enactment. Students with different learning activities show different implementations in class. For this, teachers have to use differentiating teaching methodology. There is a strong link between the intellectual ability, learning style, and personality type of the students who are learning STEM. The learning process can be improved if their teachers will take proper differentiated teaching for their students. The result of this research suggests that differentiated teaching is an educational approach that will compensate for students' personal requirements and motivations to learn meaningfully.

This research can contribute to differentiated teaching for STEM classes and other subjects. The modification approach from this study can also contribute to differentiated teaching activities in any subjects. This study will have considerable impact leading to substantial contribution to teaching STEM education in developing Asian countries like Mongolia. There is a need to develop STEM and its curriculum properly in Mongolian universities. There are fewer experienced teachers for STEM in Mongolia.

References

Al Salami, M. K., Makela, C. J., & De Miranda, M. A. (2017). Assessing changes in teachers' attitudes toward interdisciplinary STEM teaching. *International Journal of Technology and Design Education, 27*(1), 63-88. https://doi.org/10.1007/s10798-015-9341-0

Algozzine, B., & Anderson, K. M. (2007). Tips for teaching: Differentiating instruction to include all students. *Preventing school failure: Alternative education for children and youth, 51*(3), 49-54. https://doi.org/10.3200/PSFL.51.3.49-54

Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-Based Learning, 6*(2), 4. https://doi.org/10.7771/1541-5015.1349

Bagiati, A., & Evangelou, D. (2015). Engineering curriculum in the preschool classroom: the teacher's experience. *European Early Childhood Education Research Journal, 23*(1), 112-128. https://doi.org/10.1080/1350293X.2014.991099

Bruce-Davis, M. N., Gubbins, E. J., Gilson, C. M., Villanueva, M., Foreman, J. L., & Rubenstein, L. D. (2014). STEM high school administrators', teachers', and students' perceptions of curricular and instructional strategies and practices. *Journal of Advanced Academics, 25*(3), 272-306. https://doi.org/10.1177/1932202X14527952

Cassady, J. C., Speirs Neumeister, K. L., Adams, C. M., Cross, T. L., Dixon, F. A., & Pierce, R. L. (2004). The differentiated classroom observation scale. *Roeper Review, 26*(3), 139-146. https://doi.org/10.1080/02783190409554259

Cavlazoglu, B., & Stuessy, C. (2017). Changes in science teachers' conceptions and connections of STEM concepts and earthquake engineering. *The Journal of Educational Research, 110*(3), 239-254. https://doi.org/10.1080/00220671.2016.1273176

Chai, C. S., Jong, M., & Yan, Z. (2020). Surveying Chinese teachers' technological pedagogical STEM knowledge: A pilot validation of STEM-TPACK survey. *International Journal of Mobile Learning and Organisation, 14*(2), 203-214. https://doi.org/10.1504/IJMLO.2020.106181

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2014). Driven by beliefs: Understanding challenges physical science teachers face when integrating engineering and physics. *Journal of Pre-College Engineering Education Research (J-PEER), 4*(2), 5. https://doi.org/10.7771/2157-9288.1098

Davis, J. L., & Petretic-Jackson, P. A. (2000). The impact of child sexual abuse on adult interpersonal functioning: A review and synthesis of the empirical literature. *Aggression and violent behavior, 5*(3), 291-328. https://doi.org/10.1016/S1359-1789(99)00010-5

De Vore, P. W. (1992). Technological literacy and social purpose. *Theory Into Practice, 31*(1), 59-63. https://doi.org/10.1080/00405849209543525

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 37*(6), 582-601. https://doi.org/10.1002/1098-2736(200008)37:6<582::AID-TEA5>3.0.CO;2-L

Di, X. (2017). Educational philosophy–East, west, and beyond: A reading and discussion of Xueji (學記). *Educational Philosophy and Theory, 49*(5), 442-451. https://doi.org/10.1080/00131857.2016.1233092

Elfrink, V. L., Kirkpatrick, B., Nininger, J., & Schubert, C. (2010). Using learning outcomes to inform teaching practices in human patient simulation. *Nursing Education Perspectives, 31*(2), 97-100. https://europepmc.org/article/med/20455366

Erickson, C. (2010). *Differentiated instruction: Applying the work of CA Tomlinson in the primary literacy classroom*. University of Victoria. http://hdl.handle.net/1828/2599

Evans, C., & Waring, M. (2011). How can an understanding of cognitive style enable trainee teachers to have a better understanding of differentiation in the classroom? *Educational Research for Policy and Practice, 10*(3), 149-169. https://doi.org/10.1007/s10671-011-9101-1

Goodpaster, K. P. S., Adedokun, O. A., & Weaver, G. C. (2012). Teachers' perceptions of rural STEM teaching: Implications for rural teacher retention. *The Rural Educator, 33*(3). https://doi.org/10.35608/ruraled.v33i3.408

Hassan, A., & Jamaludin, N. S. (2010). Approaches & values in two gigantic educational philosophies: East and West. *Online Educational Research Journal, 1*(2), 1-15. https://oerj.webspace.durham.ac.uk/wp-content/uploads/sites/249/2021/07/9.pdf

Havnes, A., & Prøitz, T. S. (2016). Why use learning outcomes in higher education? Exploring the grounds for academic resistance and reclaiming the value of unexpected learning. *Educational Assessment, Evaluation and Accountability, 28*(3), 205-223. https://doi.org/10.1007/s11092-016-9243-z

Hochella Jr, M. F., Mogk, D. W., Ranville, J., Allen, I. C., Luther, G. W., Marr, L. C., . . . Rosso, K. M. (2019). Natural, incidental, and engineered nanomaterials and their impacts on the Earth system. *Science, 363*(6434), eaau8299. https://doi.org/10.1126/science.aau8299

Khaeroningtyas, N., Permanasari, A., & Hamidah, I. (2016). Stem learning in material of temperature and its change to improve scientific literacy of junior high school. *Jurnal Pendidikan IPA Indonesia, 5*(1), 94-100. https://doi.org/10.15294/jpii.v5i1.5797

King-Shaver, B. (2008). Differentiated instruction: The new and not so new. *California English, 13*(4), 6-8.

LaForce, M., Noble, E., & Blackwell, C. (2017). Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs. *Education Sciences, 7*(4), 92. https://doi.org/10.3390/educsci7040092

Lauria, J. (2010). Differentiation through learning-style responsive strategies. *Kappa Delta Pi Record, 47*(1), 24-29. https://doi.org/10.1080/00228958.2010.10516556

Lee, M.-H., Chai, C. S., & Hong, H.-Y. (2019). STEM education in Asia Pacific: Challenges and development. *The Asia-Pacific Education Researcher, 28*(1), 1-4. https://doi.org/10.1080/02188791.2019.1598851

Levy, H. M. (2008). Meeting the needs of all students through differentiated instruction: Helping every child reach and exceed standards. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 81*(4), 161-164. https://doi.org/10.3200/TCHS.81.4.161-164

Li, Y., Froyd, J. E., & Wang, K. (2019). Learning about research and readership development in STEM education: a systematic analysis of the journal's publications from 2014 to 2018. *International Journal of STEM Education, 6*(1), 1-8. https://doi.org/10.1186/s40594-019-0176-1

Li, Y., Wang, K., Xiao, Y., & Froyd, J. E. (2020). Research and trends in STEM education: A systematic review of journal publications. *International Journal of STEM Education, 7*(1), 1-16. https://doi.org/10.1186/s40594-020-00213-8

Lou, S.-J., Chou, Y.-C., Shih, R.-C., & Chung, C.-C. (2017). A study of creativity in CaC2 steamship-derived STEM project-based learning. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(6), 2387-2404. https://doi.org/10.12973/eurasia.2017.01231a

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education, 6*(1), 1-16. https://doi.org/10.1186/s40594-018-0151-2

Marton, F. (1996). Memorizing and understanding: The keys to the paradox? *The Chinese learner: Cultural, psychological and contextual influences, 1*(1), 69-83. https://ci.nii.ac.jp/naid/20001474586/

Richards, M. R. E., & Omdal, S. N. (2007). Effects of tiered instruction on academic performance in a secondary science course. *Journal of advanced academics, 18*(3), 424-453. https://doi.org/10.4219/jaa-2007-499

Ryu, M., Mentzer, N., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: Challenges and implications for integrated STEM teacher preparation. *International journal of technology and design education, 29*(3), 493-512. https://doi.org/10.1007/s10798-018-9440-9

Sanders, M. (2009). Integrative STEM education: primer. *The Technology Teacher, 68*(4), 20-26.

Suratno, W., B, Chang, C.-Y., Retnowati, A., & Yushardi. (2020). Exploring a direct relationship between students' problem-solving abilities and academic achievement: A STEM education at a coffee plantation area. *Journal of Turkish Science Education, 17*(2), 211-224. https://doi.org/10.36681/tused.2020.22

Tezer, M., & Karasel, N. (2010). Attitudes of primary school 2nd and 3rd grade students towards mathematics course. *Procedia-Social and Behavioral Sciences, 2*(2), 5808-5812. https://doi.org/10.1016/j.sbspro.2010.03.947

Tomlinson, C. A. (1999). Mapping a route toward differentiated instruction. *Educational leadership, 57*, 12-17. https://education.illinoisstate.edu/downloads/linc/linccurriculummodule/Tomlinson.pdf

Tomlinson, J. W., Holden, N., Hills, R. K., Wheatley, K., Clayton, R. N., Bates, A. S., . . . Stewart, P. M. (2001). Association between premature mortality and hypopituitarism. *The Lancet, 357*(9254), 425-431. https://doi.org/10.1016/S0140-6736(00)04006-X

Van Haneghan, J. P., Pruet, S. A., Neal-Waltman, R., & Harlan, J. M. (2015). Teacher beliefs about motivating and teaching students to carry out engineering design challenges: Some initial data. *Journal of Pre-College Engineering Education Research (J-PEER), 5*(2), 1. https://doi.org/10.7771/2157-9288.1097

White, D. W. (2014). What is STEM education and why is it important. *Florida Association of Teacher Educators Journal, 1*(14), 1-9. http://www.fate1.org/journals/2014/white.pdf

Yildirim, B. (2016). An Analyses and Meta-Synthesis of Research on STEM Education. *Journal of Education and Practice, 7*(34), 23-33. http://files.eric.ed.gov/fulltext/EJ1126734.pdf

Yildirim, B., & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi. *El-Cezeri Journal of Science and Engineering, 2*(2), 28-40. https://dergipark.org.tr/en/pub/ecjse/issue/4899/67132

Yıldırım, B., & Sevi, M. (2016). Examination of the effects of STEM education integrated as a part of science, technology, society and environment courses. *Journal of Human Sciences, 13*(3), 3684–3695. https://doi.org/10.14687/jhs.v13i3.3876