Breaking Barriers in STEM Learning: Effective Practices for Utilizing Universal Design for Learning and Design Thinking (UDL-DT) Module with Special Needs Students

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ABSTRACT

This study aims to highlight the inclusive STEM education teaching approach that teachers can implement for students with special educational needs (SEN) at SK Bagan Jermal. Science, Technology, Engineering and Mathematics (STEM) education at the school level is increasingly a concern and discussion in the Malaysian education system. However, STEM education among students with special educational needs (SEN) is not given due attention and is lagging in education. STEM education is important to all students including SEN students. The implementation of STEM education for SEN students presents unique and different challenges to teachers. The teaching approach through Universal Design for Learning – Design Thinking (UDL-DT) provides an inclusive learning environment that caters to the needs of all students. This approach can ensure that SEN students receive quality STEM education and develop the skills and knowledge needed to succeed in the field of STEM education. Additionally, UDL-DT can provide a class environment accessible to SEN students that may never have been considered before. This study involved three students with special education needs with the mainstream students in the STEM Club. The findings on the implementation of the UDL-DT approach based on observation, rubric analysis, and student interviews show that this approach has successfully attracted and identified the potential of SEN students in STEM education as well as improving the practice of teachers in teaching and learning process from the aspect of drafting, planning and implementing activities for SEN students.

Keywords: STEM Education, Students with Special Education Needs, Universal Design of Learning, Design Thinking

Introduction of Best Practice

UNESCO Sustainable Development Goal 4 (SDG4) is a global agenda that focuses on quality education and the Education 2030 Framework that plays an important role in inclusive education (UNESCO et al., 2015). Inclusive education in Malaysia through the Malaysian Education Development Plan (PPM) 2013-2025 was designed to achieve 75% SEN students' inclusion in Inclusive Education by 2021 to 2025. Inclusive education is a bridge that connects social inequalities and provides equal access to education for all students without any obstacles. Every student, including students with special education needs (SEN), has the right to get quality education and to develop potential as well as become competitive citizens. STEM education that emphasizes the integration of Science, Technology, Engineering and Mathematics is essential to developing skills and knowledge in 21st-century education. However, SEN student

often face barriers to accessing and participating in STEM education (Smith & Rayfield, 2019). Teachers do not have appropriate teaching methods to assist SEN students in STEM education (Diana et al., 2021). Therefore, inclusive pedagogical strategies are needed as an alternative teaching method to help increase SEN students' interest and understanding in STEM education (Siti Fatimah Salleh & Mustafa Che Omar, 2018). Therefore, this study presents an inclusive pedagogy strategy that uses a teaching and learning approach through Universal Design of Learning (UDL) and Design Thinking (UDL-DT).

Universal Design of Learning (UDL) (CAST, 2018) is a teaching and learning approach that has the potential to change STEM education towards a more inclusive direction for students with special educational needs (SEN) (Smith & Rayfield, 2019). In other words, UDL provides an inclusive teaching and learning approach to provide an accessible STEM learning environment, appeal and high-quality education to all students including SEN students (Nasri et al., 2021).

The principle of the UDL approach is based on the fact that teaching and learning should be designed to meet the needs and capabilities, regardless of abilities and learning style (Zayyad, 2019). There are three cores of the UDL principle which are:

i) Multiple Means of Representation: Provide learning information and content in different ways to support the learning of all students. The collection of information from these various means is aimed at allowing students to find out what is being studied. A teaching method that not only teaches from textbooks but provides understanding using various means such as demonstrations, visuals, audiobooks, drawings and so on.
ii) Multiple Means of Expression: Provide students with various ways to express their knowledge and understanding of what has been learned. Among the methods that can be used are oral, drawing, written and multimedia according to their capabilities.
iii) Multiple Means of Engagement: Provide opportunities for students to engage in different ways/methods to foster interest and motivation, as well as encourage active learning. This includes using technology, hands-on activities and group activities to provide collaboration opportunities and social interaction.

This UDL approach will give teachers the flexibility and freedom to plan STEM activities that meet the needs of all students including SEN students. This approach can boost inclusive education that receives every student's uniqueness which will lead to the development of a positive attitude towards STEM education especially for SEN students to achieve high-quality education.

In addition, Design Thinking skill is used to create a more challenging teaching approach that uses practical knowledge and skills. *Design Thinking* is also a method often associated with STEM education. Furthermore, this method is also used to help improve critical thinking skills and the ability to use scientific principles in problem-solving. *Design Thinking* consists of several steps i.e. emphasize, define, ideate, prototype, iterate and present. Approaches that incorporate Universal Design of Learning (UDL) and Design Thinking (DT) can provide guidelines on teaching and

learning methods that support all students including SEN students (Ballenger & Sinclair, 2020).

Justification of Best Practice

The Universal Design of Learning (UDL) and Design Thinking approach is very important in STEM education for students with special educational needs (SEN) as it is a learning approach that provides an inclusive environment. It is a learning method that is accessible and supports a wide range of students' needs and capabilities. This is because teachers in inclusive classes still need additional training and skills to improve the learning and teaching of SEN students (Zayyad, 2019). The lack of exposure and emphasis on STEM education for SEN students has left these students behind without proper attention (Smith & Rayfield, 2019). In addition, teachers' perception of SEN students' disabilities has resulted in them not being given the opportunity to study the STEM field.

Learning problems refer to the difficulty or inability experienced by a person in obtaining, understanding, storing and organizing information effectively. These problems will affect various aspects of learning such as reading, writing, mathematics, communication and language comprehension. Examples of learning problems are dyslexia (difficulty reading), dyscalculia (mathematics), ADHD (concentration disorder and hyperactivity), autism (a neurological disorder that causes difficulties in social interaction, communication and behaviour) and language disorders (difficulty understanding, and using language that causes impaired communication and understanding of instructions). However, these problems are not related to one's level of intelligence, but rather to differences in the way one processes information and learns (Zayyad, 2019).

Therefore, it is important for teachers to understand the real causes and problems as well as the teaching methods/strategies that can support the teaching and learning of SEN students, especially in STEM education. STEM education is a new education of the 21st century that students need to master for them to be accepted for work in the future. Therefore, SEN students should also be given proper educational opportunities so that these students are able to get better jobs (Gordián-Vélez, 2022). In addition, there are limited research studies related to SEN-related programs and STEM education. Students' lack of interest in STEM is growing (Qureshi & Qureshi, 2021).

STEM Challenge programs was implemented under the Inclusive Education Program (IEP) in collaboration with SK Bagan Jermal STEM Club. The STEM Challenge program utilized UDL teaching approaches and design thinking skills to develop critical thinking, problem solving skills and the application of scientific principles. This enables students to apply their knowledge and skills practically, fosters a spirit of cooperation and enhanced innovation.

Objectives of Implementation

The objectives of the implementation of this study were to:
1. Create an inclusive STEM learning environment that is accessible, attractive and effective to all students including students with special educational needs (SEN).
2. Evaluate the quality of the UDL-DT module in helping teachers implement more effective teaching and learning that meets the needs of all students including SEN students.
3. Evaluate the effectiveness of the implementation of the UDL-DT module to SEN students

Participants

The study participants consisted of three students with special education needs (SEN) who were categorized as learning problems such as "slow learner", "dyslexia" and "ADHD". These students were students in the mainstream, but due to problems in reading skills and behaviour, they have been placed in the Integrated Special Education Program (PPKI) class. This causes them to lose confidence, be embarrassed and often bullied by peers. They are often excluded and neglected in teaching and learning causing their potential to be overlooked and not given attention by teachers. Therefore, this study focused on study participants who had the ability to learn together with the mainstream students known as inclusive students. The selection of these students in this study is from those who have the ability to think and speak well. The location of the study is in SK Bagan Jermal under the Inclusive Education Program (PPI) in collaboration with the STEM Club.

Best Practice Implemented

The implementation of the study consists of several phases:
i) Phase 1: Identifying issues
ii) Phase 2: Study action planning
iii) Phase 3: Implementing action studies
iv) Phase 4: Collect and analyse data

Various sources have been consulted mainly from past literature studies as well as feedback from field experts and professionals to ensure that the UDL-DT teaching approach achieves its goals and can in turn be applied and spread widely to teachers to be used as new teaching practices to SEN students who follow inclusive classroom learning.

Phase 1: Identifying issues

In this phase, issues are identified through observations and literature studies. As a result of the researchers' observations, SEN students were not given the opportunity and exposure to STEM education in schools. STEM education is considered too difficult to teach to SEN students. SEN students are mostly given exposure to the fundamentals of agriculture, cooking and business. This is due to their limitations in reading skills, which is not a priority and teachers who do not have the knowledge and skills to teach STEM to SEN students.

The results of these observations have also been proven through literature studies that state similar problems and issues. Therefore, on the basis of the importance of inclusive STEM education to SEN students, researchers have taken the initiative to develop appropriate teaching and learning approaches implemented by teachers to SEN students towards STEM education. Construction of teaching and learning methods through the Universal Design of Learning and Design Thinking (UDL-DT) approach is done based on findings from literature studies, discussions and validation from field experts and professionals.

Phase 2: Study action planning

An action plan has been established to carry out this study. Planning is needed to ensure that this study achieves its goals and goes well. The following is an action plan for carrying out this study:

Table 1
Study Planning

No.	Study Planning
1.	Conduct discussions with teachers of SK Bagan Jermal STEM Club to reach an agreement on the implementation of the study.
2.	Joint discussion between STEM Club teachers on activities for the implementation of the "*STEM Challenge*" program.
3.	UDL-DT approach design
4.	Discussion and verification of UDL-DT by STEM field experts and professionals
5.	Run teaching and learning sessions
6.	Collect and analyze data
7.	Reflection

Phase 3: Conducting a study

In this phase, an implementation plan in the form of a teaching plan was built to ensure that each activity was carried out according to the UDL-DT approach. Here are the UDL-DT implementation steps:

Table 2
Steps to Implement the UDL-DT Approach

No.	Steps to Implement the UDL-DT Approach
1.	Objective setting
2.	Provision of materials
3.	Methods of implementation on teaching and learning
4.	Presentation
5.	Valuation
6.	Formula

Table 3
Teaching and Learning Methods

No.	Implementation of Teaching and Learning Methods
1.	The teacher plays the role of facilitator/planner for each activity.
2.	Teachers ensure that every SEN student is actively involved in the planned activities.
3.	Teachers divide SEN students into groups consisting of prime students. Each group is represented by one SEN student and three prime students (various levels).
4.	Teachers ensure that SEN students can communicate and coordinate together with the first students.
5.	Teachers guide SEN students in expressing their opinions and ideas.
6.	Positive reinforcement is given to increase SEN students' confidence and motivation.

Phase 4: Collecting and analysing data

Data collection is an important step in a study. According to Mohd Majid Konting (1990), an effective method for data collection depends on the objectives of a study. Therefore, it is important for researchers to identify effective data collection methods in accordance with the objectives of the study. In this study, researchers used field methods such as observation, rubric analysis, structured questionnaires and interviews.

Observation Method

Observation is an important method of assessment of the teaching and learning activities taking place. In this study, observations were conducted to provide the study with constructive critical feedback aimed at testing the effectiveness of teaching strategies used during the teaching and learning process. The observation process is guided by the implementation process based on the modules that have been developed and verified. Observations are recorded using cameras/videos to improve the clarity of observation. Observations are presented and summarized according to the activities involved.

Observation on the implementation of the *"STEM Challenge"* using the UDL-DT module

The results from observing the implementation of the *"STEM Challenge"* using the UDL-DT Module concluded the achievement of the objectives. The UDL-DT module is a module that uses a Universal Design of Learning approach and activities based on Design Thinking. Based on the UDL approach, three principles need to be followed by teachers, namely representation, expression and engagement. The use of teaching steps is based on Design Thinking methods namely emphasize, define, ideate, prototype, iterate and present.

The activity began with a brief explanation of the "STEM Challenge*"* program involving three students with special educational needs (SEN) who are in year 6 and year 6 students in the mainstream from various levels of high, medium and low. Each group consists of four students. Based on the observations, the researchers found that all three SEN students initially looked uncomfortable, shy and lacked confidence when placed together with the mainstream students. Yet teachers played a role in showing empathy by understanding what they felt and motivating them.

Figure 1
Demonstration by Teacher

Activity 1: Introduction
The teacher uses the demonstration/visual method to explain the difference in density, weight and type of materials using coins and aluminium paper. students are asked to provide an opinion from their observations to encourage active engagement. Teachers also encouraged SEN students to provide opinions to increase their confidence.

Activity 2: Emphasize and define
Students were then asked to build a boat using aluminium paper to accommodate the largest number of coins. Next, students are asked to identify the problems and challenges of building the boat. At first, the students were quite confused and could not understand the task to be done. Teachers guide students by stimulating thinking and associating with experience and observation. What attracted attention is that a SEN student is able to give a very good idea by associating with the concept of stability and form.

Activity 3: Ideate and prototype

The next challenge is that they are asked to sketch their boat based on the problems and challenges that have been identified. The involvement of students is very active including for SEN students. The cooperation in the groups was good, although there were also understandings that needed to be completed by the teacher. Teachers played a role in explaining the concept of challenges and the importance of collaboration in the group to produce good results.

Figure 2
Collaboration and Involvement of Students in Activities

The concept of the challenge is to test the ability of students to identify factors that influence sustainability through their own experiments. They were asked to sketch and test three times and record the results of their observations in the forms provided. They were also asked to state the reasons and suggestions for improvements. The ability to observe is very important for them to understand the concept of science and not just through theoretical understanding.

Observations showed that students provide excellent cooperation through active involvement with SEN students. They also practised a tolerant attitude and gave SEN students the opportunity to jointly solve the challenges.

Activity 4: Iterate and present

Next, students are required to present the results of the experiment. The results of the observation showed that the students including SEN students were able to conduct the experiment well and formulate their own findings by linking the causes to draw conclusions. The presentation was very well done and the SEN students were also able to present well and confidently.

In conclusion, activities using the UDL-DT Module are suitable for implementation at various levels of capability. The activities gained the students' interest and stimulated their ability to think creatively and innovatively. Collaboration between students including SEN students helped to increase confidence and self-esteem and they were also able to learn together with their peers.

Rubric Analysis Assessments

Rubric analysis is an assessment built to determine the level of student's mastery of the activities that have been carried out. This rubric analysis consists of six evaluation criteria, namely Design Thinking process skills, creativity and innovation, collaboration and communication, content knowledge, UDL implementation and overall performance. The rating scale is 1 to 4, that is, 1 is the weakest and 5 is the most excellent. The highest number is 24 and the lowest is 6. Table 6 lists the criteria for the assessment of the activities of students by teachers.

Table 6
Rubric Analysis Assessments

No.	Criteria	S1	S2	S3
1	Design Thinking process skills	4	4	3
2	Creativity and innovation	4	4	3
3	Collaboration and communication	4	4	3
4	Content knowledge	3	3	3
5	UDL implementation	3	3	3
6	Overall performance	4	4	3
	NUMBER OF ACHIEVEMENTS	22	22	18

The results of the assessment found that the study participants were able to master the whole activity well, i.e. the number of achievements of each student was at a good and excellent level.

UDL-DT Module Quality Assessment Questionnaire

Quality assessment of UDL-DT modules is important in ensuring the effectiveness and suitability of modules for teaching and learning purposes. A total of three teachers involved in the STEM Club were invited to jointly evaluate the effectiveness of the activities based on the modules built. Table 7 is an analysis of the questions conducted on teachers to assess the quality of the UDL-DT Module.

Table 7

Analysis of Teachers' Questions on the Quality of UDL-DT Modules

Statement	Strongly Disagree	Disagree	Strongly Agree	Very Agree	Min	Standard Deviation
This module corresponds to the level of ability of the student.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
This module helps students master STEM education skills.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
This module provides quality teaching materials/resources.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
This module provides motivation to deliver teaching.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
This module has elements of creativity and activities that are of interest to the students.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
Will use this module in the future.	0 (0%)	0 (0%)	0 (0%)	3 (100%)	4.0	0
SUM					4.0	0

The findings show that the overall mean average of the UDL-DT Module Quality Assessment is 4.0, the average standard deviation is 0 and is in high interpretation indicating that this module is very suitable for use and application.

The findings from the comments provided by the teachers stated that this module is suitable for use at various levels of students' ability. The activities carried out can generate ideas by using ready-made experiences and reinforce the mastery of the students. In addition, the teaching methods were able to stimulate interest and creativity.

Interview Analysis

Interviews were conducted by researchers to obtain information on the effectiveness of the activities that have been carried out. This interview was conducted to get clearer and stronger feedback on the experience of the activities that have been carried out. We used six question items to get feedback on the three students involved in the study. Table 8 is a list of the interview question items in the form of a closed question based on the answers 'yes' and 'no'.

Table 8
Interview Analysis

Statement	S1		S2		S3	
	Yes	No	Yes	No	Yes	No
Do STEM activities interest you?	/		/		/	
Did the STEM activities help to understand the concepts of science, technology, engineering and mathematics?	/		/		/	
Did the STEM activities develop creative and innovative thinking skills?	/		/		/	
Do you feel more confident to participate in STEM activities after going through these activities?	/		/		/	
Do you feel more interested in participating in STEM activities in the future?	/		/		/	
Do you feel that these STEM activities help improve team skills and collaboration?	/		/		/	

Findings

The findings of this study discuss the collection and analysis of data that has been collected. The study uses observation methods, evaluation rubric analysis, questionnaires and interviews. These methods were chosen to ensure that the findings meet the objectives of the study.

Some of the findings of the study were achieved through questionnaires on two STEM teachers to assess the activities in the UDL-DT Module. Both teachers are directly involved in assessing the quality of the UDL-DT Module. The findings showed that the quality of the UDL-DT Module is at a high interpretation of quality. Both teachers strongly agreed that the UDL-DT Module should be used as one of the alternative teaching approaches suitable for all students. They also agreed that this module was easy to implement and also agreed for usage in the future. In addition, it contains activities that can stimulate the interest and creativity of students. This is in line with the findings by Qureshi & Qureshi (2021) that teachers need new, more interesting teaching methods instead of focusing on the exam pattern approach. Moreover, there is a lack of knowledge of teachers on basic concepts in preparing innovative teaching methods. Thus, the UDL-DT Module provides an understanding of the basic concepts of science and provides innovative thinking to attract students' interest and motivation towards STEM education.

As a result of the observation, all students including SEN students managed to complete the challenge very well. They are able to think creatively and innovatively and are able to relate the basic theory of science, observation, and experience to be able to draw conclusions by linking the theory and observation of the experiments that have been carried out. Active engagement, communication and collaboration between students provide inclusive learning and can enhance social interaction, confidence and motivation in SEN students. This is also in line with the results of interviews conducted on SEN students, showing that they are also able to learn together with other peers and get the same quality of education through pedagogical modification and assessment (Aida A. Rahman & Woollard, 2019).

Therefore, the right to education must be fought to provide equal educational opportunities as well as to discover the potential and talents that come with it. This is because the dropout of SEN students either in the mainstream or in PPKI is due to the "hidden abilities" aspect. "Hidden abilities" are often misinterpreted by assuming that they are incapable of getting a peer-to-peer education. This affects their self-esteem and future lives (Aida A. Rahman & Woollard, 2019). Therefore, it is important for teachers to realize that SEN students are able to pursue learning in the Inclusive Education system with support and assistance in terms of curriculum modification and assessment.

Impact of Best Practices Implemented

STEM education plays an important role in preparing future generations of innovators. Yet traditional teaching and learning practices discourage thinking as innovators. Therefore, the knowledge and role of teachers should change in accordance with the needs of present education. The results showed that students lost interest in STEM education. This is due to the fact that many teaching methods explain concepts and theories. This makes them unable to associate the theories learned in the classroom with the real world (Qureshi & Qureshi, 2021). STEM teaching methods that focus on exam approaches result in SEN students not being given opportunities in STEM education. They are often marginalized in obtaining quality education,

Therefore, this study can provide opportunities for SEN students in STEM education. This alternative pedagogical strategy approach helps SEN students understand the concepts of STEM education, establish collaboration within the group as well and improve self-confidence and communication skills.

Summary and Recommendation

New skills and knowledge to teachers should be inclusive to implement inclusive STEM education. Teachers should understand the needs and capabilities of SEN students which requires a different approach compared to mainstream students. This will also enhance the competency and skills of teachers in managing SEN students in an inclusive environment.

Therefore, in ensuring the successful implementation of inclusive education, it is proposed that this inclusive STEM education be a highlightable program that can benefit all students, especially SEN students. SEN students should also be given equal rights and opportunities in the thriving STEM education. This UDL-DT module can also promote inclusive education that values every difference and provides equal opportunities to all students and an inclusive community environment.

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