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OVERALL OBSERVATION REPORT

INTRODUCTION

The intended purpose of the observations was to improve the implementation of STEM integrated curriculum in our project. In opposite, not to judge or criticize. This a collaborative learning process from each of us. That's why, we have reported our findings anonymously.

The first step of quality is to define the missing parts, deficiencies, or weaknesses. The deficiencies and weaknesses are the urgent areas that should be improved. That's why, we compiled our findings on basis of SWOT analysis, and we have respectively proposed some suggestions regarding the mobilities.

What did we do in the observations?

We have observed the implementation of science, technology, engineering, and mathematics (STEM) integration in the lessons. Based on STEM integration, we have observed eight category design process developed by Zhou et al. (2023)*: Define, Learn, Plan, Try, Test, Decide, Improve, and Instructional Strategies (see Appendix 1.)

* Zhou, S., Merzdorf, H. E., Douglas, K. A., & Moore, T. J. (2023). Development and Validation of an Integrated STEM Teacher Classroom Observation Protocol. Journal of Pre-College Engineering Education Research (J-PEER), 13(1), 2.

LITHUANIA OBSERVATIONS

Steps	Objectives	Scale				
		Very Poor	Poor	Acceptable	Good	Very Good
Define	Teacher explains the design process as a decision- making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.		X			
	Teacher asks students to identify criteria/constraints, and trade-offs of the problem.		X			
	Teacher helps students to tell identify the end-user land the client.		X			
	Teacher challenges students to learn more about the problem.			X		
	Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.			X		
Learn	Teacher emphasizes the fundamental science/ mathematics concepts related to the engineering design problem while making connections to the engineering design problem.				X	
	Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.				X	
Plan	Teacher expects students to generate a variety of potential solution ideas.				X	
	Teacher encourages students to continue to define the problem as they generate ideas.			X		
	Teacher instructs students to select a design from multiple solutions based on their evidence.				X	
	Teacher instructs students to communicate how they make their design decisions based on the evidence.				X	
	Teacher instructs students to work out details of their design ideas for the design they select.			X		
Try	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.				X	
	Teacher instructs students to optimize their prototype when they develop the design.				X	
Test	Teacher has students follow up test procedures to answer testable questions of problems to collect data.				X	
	Teacher requires students to analyze and interpret collected data.			X		
Decide	Teacher gives students opportunities to communicate and justify their design.			X		
	Teacher requires students to use evidence to evaluate their design.			X		
Improve	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.			X		
	Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.			X		
Instructional Strategies	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.				X	
	Teacher uses multiple forms of representations to help students to learn concepts.				X	
	Teacher promotes the development and application of models for developing deep thinking skills.			X		

Despite, the Lithuania mobility was the first training mobility in the project;

- There were nice activities to take attention of the students (Mining activity, etc.).

- The subjects of the lessons were mostly related to STEM approach except one.
- Few teachers encouraged students to identify the problem.
- In one lesson, basic STEM concepts were explained (eg. Science, technology, client, end-user, manufacturer, etc).
- In one lesson, the teacher told science, maths, engineering knowledge related to the lesson topic.
- Some teachers encouraged task sharing in the groups (eg., solar engineer, material engineer, etc.)
- Few teachers mentioned about the constraints and criteria of the design problem.
- Few teachers tried to follow the EDP steps in her/his instruction.

In most of the lessons,

- There were general problems. However, real life problem was slightly there. The definition of the real-life problem was not clear enough. Why was that problem important? It was not explained or discussed well enough.
- Most teachers did not follow the EDP steps in her/his instruction enough.
- Constraints and criteria were not identified.
- Engineering Design Process (EDP) was not explained at the beginning of the lessons except one lesson. The lessons were not planned according to EDP as well. However, the core of the STEM based lesson is using a design process.
- Client, customer and end-user were not described enough.
- In one lesson, there was not STEM activity or a STEM problem. It was based on a behaviorist approach by using lecture method. In that lesson, the students were passive learners since a kind of teacher-centered instruction was used.

BULGARIA OBSERVATIONS

Steps	Objectives	Scale				
		Very Poor	Poor	Acceptable	Good	Very Good
Define	Teacher explains the design process as a decision- making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.			X		
	Teacher asks students to identify criteria/constraints, and trade-offs of the problem.			X		
	Teacher helps students to tell identify the end-user land the client.				X	
	Teacher challenges students to learn more about the problem.				X	
	Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.				X	
Learn	Teacher emphasizes the fundamental science/ mathematics concepts related to the engineering design problem while making connections to the engineering design problem.				X	
	Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.				X	
Plan	Teacher expects students to generate a variety of potential solution ideas.				X	
	Teacher encourages students to continue to define the problem as they generate ideas.				X	
	Teacher instructs students to select a design from multiple solutions based on their evidence.				X	
	Teacher instructs students to communicate how they make their design decisions based on the evidence.				X	
	Teacher instructs students to work out details of their design ideas for the design they select.				X	
Try	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.					X
	Teacher instructs students to optimize their prototype when they develop the design.				X	
Test	Teacher has students follow up test procedures to answer testable questions of problems to collect data.					X
	Teacher requires students to analyze and interpret collected data.				X	
Decide	Teacher gives students opportunities to communicate and justify their design.			X		
	Teacher requires students to use evidence to evaluate their design.				X	
Improve	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.				X	
	Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.			X		
Instructional Strategies	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.				X	
	Teacher uses multiple forms of representations to help students to learn concepts.				X	
	Teacher promotes the development and application of models for developing deep thinking skills.				X	

SLOVAKIA OBSERVATIONS

Steps	Objectives	Scale				
		Very Poor	Poor	Acceptable	Good	Very Good
Define	Teacher explains the design process as a decision- making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.				X	
	Teacher asks students to identify criteria/constraints, and trade-offs of the problem.			X		
	Teacher helps students to tell identify the end-user land the client.				X	
	Teacher challenges students to learn more about the problem.					X
	Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.					X
Learn	Teacher emphasizes the fundamental science/ mathematics concepts related to the engineering design problem while making connections to the engineering design problem.				X	
	Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.				X	
Plan	Teacher expects students to generate a variety of potential solution ideas.				X	
	Teacher encourages students to continue to define the problem as they generate ideas.				X	
	Teacher instructs students to select a design from multiple solutions based on their evidence.					X
	Teacher instructs students to communicate how they make their design decisions based on the evidence.				X	
	Teacher instructs students to work out details of their design ideas for the design they select.				X	
Try	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.					X
	Teacher instructs students to optimize their prototype when they develop the design.				X	
Test	Teacher has students follow up test procedures to answer testable questions of problems to collect data.					X
	Teacher requires students to analyze and interpret collected data.					X
Decide	Teacher gives students opportunities to communicate and justify their design.				X	
	Teacher requires students to use evidence to evaluate their design.					X
Improve	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.				X	
	Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.				X	
Instructional Strategies	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.					X
	Teacher uses multiple forms of representations to help students to learn concepts.					X
	Teacher promotes the development and application of models for developing deep thinking skills.				X	

TURKIYE OBSERVATIONS

Steps	Objectives	Scale				
		Very Poor	Poor	Acceptable	Good	Very Good
Define	Teacher explains the design process as a decision- making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.				X	
	Teacher asks students to identify criteria/constraints, and trade-offs of the problem.			X		
	Teacher helps students to tell identify the end-user land the client.			X		
	Teacher challenges students to learn more about the problem.				X	
	Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.			X		
Learn	Teacher emphasizes the fundamental science/ mathematics concepts related to the engineering design problem while making connections to the engineering design problem.					X
	Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.				X	
Plan	Teacher expects students to generate a variety of potential solution ideas.				X	
	Teacher encourages students to continue to define the problem as they generate ideas.				X	
	Teacher instructs students to select a design from multiple solutions based on their evidence.				X	
	Teacher instructs students to communicate how they make their design decisions based on the evidence.				X	
	Teacher instructs students to work out details of their design ideas for the design they select.			X		
Try	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.				X	
	Teacher instructs students to optimize their prototype when they develop the design.			X		
Test	Teacher has students follow up test procedures to answer testable questions of problems to collect data.			X		
	Teacher requires students to analyze and interpret collected data.			X		
Decide	Teacher gives students opportunities to communicate and justify their design.			X		
	Teacher requires students to use evidence to evaluate their design.				X	
Improve	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.				X	
	Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.				X	
Instructional Strategies	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.					X
	Teacher uses multiple forms of representations to help students to learn concepts.					X
	Teacher promotes the development and application of models for developing deep thinking skills.				X	

POLAND OBSERVATIONS

Steps	Objectives	Scale				
		Very Poor	Poor	Acceptable	Good	Very Good
Define	Teacher explains the design process as a decision- making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.			X		
	Teacher asks students to identify criteria/constraints, and trade-offs of the problem.		X			
	Teacher helps students to tell identify the end-user land the client.		X			
	Teacher challenges students to learn more about the problem.					X
	Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.				X	
Learn	Teacher emphasizes the fundamental science/ mathematics concepts related to the engineering design problem while making connections to the engineering design problem.					X
	Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.					X
Plan	Teacher expects students to generate a variety of potential solution ideas.				X	
	Teacher encourages students to continue to define the problem as they generate ideas.				X	
	Teacher instructs students to select a design from multiple solutions based on their evidence.				X	
	Teacher instructs students to communicate how they make their design decisions based on the evidence.				X	
	Teacher instructs students to work out details of their design ideas for the design they select.			X		
Try	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.			X		
	Teacher instructs students to optimize their prototype when they develop the design.			X		
Test	Teacher has students follow up test procedures to answer testable questions of problems to collect data.			X		
	Teacher requires students to analyze and interpret collected data.			X		
Decide	Teacher gives students opportunities to communicate and justify their design.				X	
	Teacher requires students to use evidence to evaluate their design.				X	
Improve	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.			X		
	Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.			X		
Instructional Strategies	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.					X
	Teacher uses multiple forms of representations to help students to learn concepts.					X
	Teacher promotes the development and application of models for developing deep thinking skills.			X		

CONCLUSION and SUGGESTIONS

In **define step,** most teachers have started to define the problem and given interesting examples. Teachers usually instructed students to further discover aspects of the problem and asked questions to students about their understanding of the problems.

The activities have generally taken attention of the students and kept the students busy. The subjects of the lessons were almost related to STEM approach. Besides, most teachers encouraged students to identify the problem. In some lessons, fundamental STEM concepts were explained well enough.

Although, a kind of design process was used in all lesson plans, few teachers described the design process well, and guided students according to that in the first trainings. However, this was improved through the last trainings. Teachers have started to cover the key aspects of the design process in the next mobilities. However, in the last mobility we have seen regression in this objective.

In most lessons, the teachers have also used activity sheets which were useful. In some lessons, the engineering/life problem was narrated via stories. This was a good strategy for gaining the interest of the students. Since, STEM Lessons must start with a real life problem and must end with a product. From the problem to product a series of process is run. That is a design process cycle.

"Constraints and Criteria" were not defined and detailed precisely. This was weakest step from the first to the last training. We can add needs of clients and end-users to this weakness. In brief, teachers rarely asked students what each stakeholder needs. Teachers rarely asked students to identify the criteria/constraints of the problem and introduced the end-user and the client.

Regarding **learn step**, the teachers emphasized and discussed the fundamental science, technology, engineering and maths concepts, although it wasn't good at the beginning. They guided students to do research about the problem from internet etc. Even, some teachers asked the students what kind of scientific knowledge that they have learnt. They also tried to connect scientific or mathematics concepts to design problems.

As for the **plan step,** activity sheets were used for planning in most lessons. Even though the majority of teachers encouraged a variety of solution approaches and refrained from judging the potential ideas, there were instances where the teachers in some lessons prescribed a specific solution to the students. On the contrary, we want the students to find possible solutions for the engineering/life problem in their own, and to choose the best solution in STEM activities. In addition, in some lessons, the students were not able understand the engineering/life problem well. If they cannot understand the problem, STEM education fails. Therefore, teachers should encourage students to think about the problem differently and should instruct them to compare multiple solutions. In addition, they should instruct students to consider how well their design met the clients' needs.

Regarding the **try step,** there was a product at the end in almost every lesson. However, in some lessons, the students were alone in this step. The teachers may guide and give feedback them regularly. That's why, while the groups are working on their task, the teachers must try to guide students more with key questions which may foster them to think. In all lessons, teachers provided student materials that they needed. However, students were not able to keep in mind criteria/constraints when they build their design well.

In test step, the students usually tested their prototypes. However, there were no product to test in a few lessons. The teachers only conducted science experiments. Sometimes, teachers asked students to make predictions about their test results. However, they rarely instructed students to

consider the criteria and constraints of the problem during testing. They gave students opportunities to carry out the experiments and asked students to record and analyze the experiment data.

In **decide and improve steps,** the students have told why and how they made their products. This can be partially a deciding process. But it was not exactly a deciding process. In a few lessons, the teachers guided the students to make modification after testing their prototypes. These steps were almost missing or very weak in most lessons.

Teachers sometimes encouraged students to discuss what was successful about their design. However, they rarely instructed students to apply learned core mathematics/science concepts to evaluate their design.

As for **the instructional strategies,** the teachers emphasized the task-sharing. The group members had different roles. Most teachers visited each group, corrected misconceptions, and give feedback.

They also identified students' roles during teamwork and encouraged them to contribute to group work. They tried to instruct students to have discussions with each other to solve problems. They provided specific feedback as necessary. They respected students' ideas and invited them to share ideas. Each student team presented their designs.

In conclusion, it can be argued that there was an overall improvement in all steps of STEM lessons from the first to the last training.

As for the suggestions, the STEM activities take more time. It is difficult to implement STEM lessons efficiently in limited times. That's why, more time is needed for the implementation of STEM activities. It is better to share more time for the STEM Lessons in schedules.

Design process steps are very important in STEM approach. So, while preparing the STEM lesson plans, a design process should be included such as EDP, and should be followed in the instructions. Besides, the used design process method should be explained to the students. Since, the students will use that method in the activities.

In the lessons, we should emphasize a real-life problem and try to define the problem more in detail. A story may be presented at the beginning of the activities. Then, students can be encouraged to determine the problem in order to take attention and motivate the students. Starting the lesson with an activity will attract the student's interest in the subject.

Some steps of the engineering design process (EDP) were unsatisfactory at beginnings of the mobilities. However, in the following mobilities, most EDP steps were improved. In spite of this improvement, teachers should especially focus on brainstorming, test and improve steps more. Further, we should avoid from long theoretical lectures in STEM approach. Using student-centered approach with a design process will be more effective and will enable students to be more active in lessons.

Appendix 1. Integrated STEM Teacher Classroom Observation Form[1]

This observation form aimed to assess teachers' implementation of science, technology, engineering, and mathematics (STEM) integration. The intended purpose of the observation form is for researchers to examine how teachers implement the STEM integrated curriculum. Based on STEM integration, the form covers eight categories: Define, Learn, Plan, Try, Test, Decide, Improve, and Instructional Strategies. The form will be reviewed by a panel of integrated STEM education experts, engineering design experts, and educational assessment experts and revised accordingly.

Activity Topic: …….. Activity Venue: ……..

Activity Date: …….. Activity Hour: ……:…… Instructor's Country: …… Observer's Name-Surname: ……..……

		Rubric				
	Pedagogical content goals	**Objectives**	**Sub-objectives**			**Notes**
Define	Teacher presents the engineering challenge and introduces/reviews the design process. Teacher facilitates students to understand the scope of the problem by asking questions and interacting with the client. Teacher encourages students to consider what is the fundamental need of stakeholders in the problem.	Teacher explains the design process as a decision-making process based on evidence that results in technology. Teacher asks students questions to prompt their thinking about what the problem is from the perspective of stakeholders.	Covers key aspects of the design process.	yes	no	
			Asks students to describe the whole process.	yes	no	
			The result of process is technology.	yes	no	
			Instructs students to further discover aspects of the problem.	yes	no	
			Asks questions to students about their understanding of the problems.	yes	no	
			Asks students what each stakeholder needs.	yes	no	
			Asks students why the problem is important to them.	yes	no	
		Teacher asks students to identify criteria/constraints, and trade-offs of the problem. Teacher helps students to tell identify the end-user and the client.	Asks students to identify the criteria/constraints of the problem.	yes	no	
			Asks students to identify trade-offs of the problem.	yes	no	
			Introduces the end-user.	yes	no	
			Asks students to define the end-user.	yes	no	
			Introduces the client, if there is a client.	yes	no	
			Asks students to define the client, if there is a client.	yes	no	
			Asks students to differentiate between an end-user and a client, if there is a client.	yes	no	
		Teacher challenges students to learn more about the problem.	Questions what content students will need to learn about the problem.	yes	no	
			Questions how students could find/learn information.	yes	no	
			Instructs students to identify what criteria and constraints are important.	yes	no	
			Challenges students' assumptions about the problem (why?).	yes	no	
		Teacher allows students to explain why the problem is important, using information from the client and stakeholders to support the reasons.	Ask students whether the problem is important.	yes	no	
			Instructs students to explain why the problem is important.	yes	no	
			Instructs students to provide rationale from client information.	yes	no	
Learn	Teacher gives students the opportunity to build their knowledge for the design through research for the purpose of developing design solutions. The research informs their design and allows them to further scope the problems. This research can include mathematics and science concepts, and other strategies.	Teacher emphasizes the fundamental science/mathematics concepts related to the engineering design problem while making connections to the engineering design problem.	Discusses relevant science/mathematics concepts.	yes	no	
			Connects scientific or mathematics concepts to design problems.	yes	no	
			Questions students to identify what about the concepts can inform design.	yes	no	
		Teacher gives students opportunities to learn background information to inform their design and understanding of the problem.	Instructs students to do research about the problem, e.g., from written sources, surveys, interviews, etc.	yes	no	
			Asks what existing design, product, or solution fills a similar need.	yes	no	
			Asks students to identify what informational knowledge they need to learn.	yes	no	
			Facilitates students to learn informational knowledge.	yes	no	

[1] Zhou, S., Merzdorf, H. E., Douglas, K. A., & Moore, T. J. (2023). Development and Validation of an Integrated STEM Teacher Classroom Observation Protocol. Journal of Pre-College Engineering Education Research (J-PEER), 13(1), 2.

		Rubric				
	Pedagogical content goals	**Objectives**	**Sub-objectives**			**Notes**
Plan	During idea generation, teacher supports students to continue to define the problem as they generate a wide variety of solution paths and ideas. Teacher does not judge student ideas at this point and supports students to openly consider many ideas.	Teacher expects students to generate a variety of potential solution ideas.	No judgements of potential ideas.	yes	no	
			Encourages a variety of solution approaches.	yes	no	
			Instructs students to consider simplifying assumptions in order to help generate ideas. (This does not fit for K-2.)	yes	no	
		Teacher encourages students to continue to define the problem as they generate ideas.	Recalls or points students to look back at criteria and constraints.	yes	no	
			Challenges students to think about the problem differently.	yes	no	
	During idea selection, teacher instructs students to select potential solutions from multiple design ideas based on evidence learned about the problem. Teacher instructs students to communicate the details of their design ideas, the decisions that students made, and how they justify their decisions with evidence.	Teacher instructs students to select a design from multiple solutions based on their evidence.	Instructs students to compare multiple solutions.	yes	no	
			Instructs students to think about the trade-offs of each of their design plans.	yes	no	
			Instructs students to make decisions using mathematics concepts as evidence.	yes	no	
			Instructs students to make decisions using science concepts as evidence.	yes	no	
			Provides students the opportunity to state which solution was chosen.	yes	no	
			Instructs students to consider how well their design meets clients' needs.	yes	no	
			Accepts evidence that might also come from other sources/concepts beyond mathematics or science.	yes	no	
		Teacher instructs students to communicate how they make their design decisions based on the evidence.	Provides students the opportunity to communicate why design choices were made.	yes	no	
			Provides students the opportunity to communicate how parts of the design work.	yes	no	
			Provides students the opportunity to communicate how the design meets the criteria and constraints.	yes	no	
			Has students communicate how mathematics and science concepts inform their design.	yes	no	
			Has students communicate what design decisions they make and why.	yes	no	
		Teacher instructs students to work out details of their design ideas for the design they select.	Instructs students to represent their design idea.	yes	no	
			Instructs students to label important parts of the design.	yes	no	
			Instructs students to describe how their design works.	yes	no	
Try	Teacher facilitates students to put the plan into action by building a testable representation of a solution (e.g., building prototype, process). Teacher instructs students to make modifications of their prototype in order to better meet criteria/constraints if needed .	Teacher instructs students to build a prototype, model, or product for the design they selected from plan.	Provides student materials that they needed.	yes	no	
			Has students keep in mind criteria/constraints when they build their design.	yes	no	
			Has students keep in mind clients' need when they build their design.	yes	no	
			Has students keep in mind science/mathematics concepts from Learn stage.	yes	no	
		Teacher instructs students to optimize their prototype when they develop the design.	Instructs students to consider weaknesses of a prototype.	yes	no	
			Instructs students to modify their prototype to follow their plan if needed.	yes	no	
			Requires students to consider the trade-offs.	yes	no	
Test	Teacher instructs students to consider testable questions about the performance of their design prototype, model or product. Teacher has students collect specific results from the test and instructs students to analyze their collected results for evaluating solution performance.	Teacher has students follow up test procedures to answer testable questions of problems to collect data.	Instructs students to consider testable questions of problems during testing.	yes	no	
			Asks students to make predictions about their test results.	yes	no	
			Instructs students to consider the criteria and constraints of the problem during testing.	yes	no	
			Gives students opportunities to carry out the experiments.	yes	no	
		Teacher requires students to analyze and interpret collected data.	Asks students to record the experiment data.	yes	no	
			Asks students to analyze the test data.	yes	no	
			Requires students to explain the advantages of design found from data analysis.	yes	no	
			Requires students to explain drawbacks of design found from data analysis.	yes	no	

		Rubric				
	Pedagogical content goals	**Objectives**	**Sub-objectives**			**Notes**
Decide	Teacher asks students to decide the overall performance of their design. Teacher instructs students to communicate and justify whether their design decision is appropriate based on evidence.	Teacher gives students opportunities to communicate and justify their design.	Provides students the opportunity to communicate their design as a synthesis.	yes	no	
			Encourages to include the evidence from the testing result as a justification.	yes	no	
			Teacher encourages to justify based on a correct understanding of mathematics/science concepts.	yes	no	
			Encourages students to discuss what was successful about their design.	yes	no	
		Teacher requires students to use evidence to evaluate their design.	Instructs students to apply results (e.g., data) gathered from testing to evaluate their design.	yes	no	
			Instructs students to apply learned core mathematics/science concepts to evaluate their design.	yes	no	
			Asks students to consider whether their design stays within criteria/constraints.	yes	no	
			Asks students to consider how their design balances trade-offs.	yes	no	
Improve	Teacher gives students the opportunity to revisit the solution, and make changes and improvements based on an understanding of the problem and results. Teacher instructs students to improve the performance of chosen solution (i.e., redesign) and provides students with opportunities to learn from failure.	Teacher asks students to decide whether their design needs improvement and communicates how their design could be improved if needed.	Requires students to use test results as evidence for improvement or no improvement.	yes	no	
			Encourages students to discuss how their design could be improved based on their test results and feedback from the client/user.	yes	no	
			Requires students to explain the rationale for improvements based on test results.	yes	no	
			Requires students to explain the rationale for improvements based on a correct understanding of mathematics/science concepts.	yes	no	
			Requires students to list planned improvements.	yes	no	
		Teacher asks students to redesign their solution based on the performance of the prototype. Teacher provides students with opportunities to learn from failure.	Instructs students to redefine the problem.	yes	no	
			Instructs students to replan.	yes	no	
			Instructs students to retry.	yes	no	
			Instructs students to retest,	yes	no	
			Facilitates student conversations about failure for purpose of improvement.	yes	no	
			Teacher gives students feedback on planned improvements, i.e, redesign, but without directly telling what students can do.	yes	no	

		Rubric				
	Pedagogical content goals	**Objectives**	**Sub-objectives**			**Notes**
Instructional Strategies	Teacher gives students the opportunity to construct their learning and promotes teamwork. Teacher is the facilitator of students' learning, and teacher emphasizes dialogues with students and teacher responds in a way that meets their learning needs.	Teacher promotes collaborative and cooperative learning in teamwork.	Instructs students to identify their roles during teamwork.	yes	no	
			Encourages students to contribute to group work.	yes	no	
			Encourage students to help team members confront problems.	yes	no	
			Instructs students to have discussions with each other to solve problems.	yes	no	
			Helps students to consider different viewpoints from each teammate.	yes	no	
			Promotes students to give peer feedback.	yes	no	
		Teacher uses scaffolding instruction, which allows students to be responsible for their own learning. Teacher gives students constructive feedback.	Communicates students' responsibility during the instruction.	yes	no	
			Fades his/her own support during the instruction.	yes	no	
			Provides specific feedback as necessary.	yes	no	
			Provides forward thinking feedback.	yes	no	
			The feedback teacher provides is worded as a question sometimes.	yes	no	
			Gives frequent feedback to students.	yes	no	
	Teacher promotes a student-centered approach. Teacher encourages students to look at problems in multiple ways and probes students' conceptual understanding.	Teacher gives students a voice in the class, seeks students' contribution, and adapts instruction according to students' needs.	Respects students' ideas and invites students to share ideas.	yes	no	
			Actively solicits student ideas and builds on these conceptions and ideas during instruction.	yes	no	
			Demonstrates consideration for the pacing of a lesson based on students' progression from whole unit perspectives.	yes	no	
		Teacher uses multiple forms of representations to help students to learn concepts.	Uses at least two forms of representations to help students explain the concept.	yes	no	
			Translates between representations to help students explain the concept.	yes	no	
			Encourages students to use multiple forms of representations.	yes	no	
			Encourages students to translate between representations to explain the concept.	yes	no	
		Teacher promotes the development and application of models for developing deep thinking skills.	Instructs students to develop models for representing the problems.	yes	no	
			Instructs students to apply models to guide their design.	yes	no	