Interactive Music Science Collaborative Activities

Team Teaching for STEAM Education

Deliverable 2.5

Final Evaluation metrics for deeper learning with iMuSciCA

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Executive Summary

This deliverable reports on the final evaluation metrics for deeper learning with iMuSciCA. This evaluation metrics will be used during the piloting phase B (see D6.1: Pilot Testing Action Plan) of the project and it will be based on an iterative process of responsive evaluation. The results of this evaluation will form the basis for a cycle of optimization of the iMuSciCA learning environment. The aim of the evaluation is to see if iMuSciCA can address deeper learning in a reasonable way and to provide valuable information on how to improve the iMuSciCA environment to this purpose.

First we describe how the framework for deeper learning, described in *D2.2: Initial Evaluation Metrics for Deeper Learning With iMuSciCA*, was further implemented by iMuSciCA in view of the evaluation in classroom situations. Then, we briefly describe the methodology for the iMuSciCA evaluation as related to the piloting. Finally, we describe the newly adapted metrics and the tools developed after delivering D2.2, with the corresponding specific templates for the assessment of the deeper learning competencies.

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LIST OF ABBREVIATIONS

Abbreviation	Description
PU	Public Report
WP	Work Package
STEM	Science, Technology, Engineering and Maths
STEAM	Science, Technology, Engineering and Maths combined with Arts
IBSE	Inquiry Based Science Education
ATHENA	ATHENA RESEARCH AND INNOVATION CENTER IN INFORMATION COMMUNICATION & KNOWLEDGE TECHNOLOGIES
UCLL	UC LIMBURG
EA	ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE
IRCAM	INSTITUT DE RECHERCHE ET DE COORDINATION ACOUSTIQUE MUSIQUE
LEOPOLY	3D FOR ALL SZAMITASTECHNIKAI FEJLESZTO KFT
CABRI	Cabrilog SAS
WIRIS	MATHS FOR MORE SL
UNIFRI	UNIVERSITE DE FRIBOURG

1. Introduction

One of the aims of STEAM education is to promote aspects of education that cannot be addressed within single discipline teaching. These aspects can refer to the content of learning as well as to the context and approaches of learning (Honey et al., 2014; Quigley et al., 2017; Czerniak & Johnson, 2007).

As iMuSciCA follows an interdisciplinary STEAM approach, it helps create the awareness that, only by discovering different aspects of the same, one can see more: the 'more' that you cannot see when you stay within one discipline. STEAM works on the transfer of concepts and skills from one content area to another. It examines the same phenomenon in different ways and from different stances (Quigley et al., 2017; Frans et al., 2013).

The inclusion of concepts or practices from different subject areas in iMuSciCA is intended to deepen the learning and the understanding of the targeted STEAM subjects. The hypothesis of the iMuSciCA project is furthermore that learners can interact with these different viewpoints of STEAM, that these interdisciplinary views will free deep motivation of learners for the STEAM-world. The potential for iMuSciCA in realizing these goals will be assessed during the piloting evaluation the outcomes of which aim to improve the pedagogy, the lesson plans, and the workbench.

2. The application of deeper learning in iMuSciCA

2.1. Framework of deeper learning

As previously pointed out in WP2 and WP6 (e.g. *D2.2 - Initial Evaluation Metrics for Deeper Learning With iMuSciCA* and *D6.1 - Pilot Testing Action Plan*), the iMuSciCA evaluation framework is based on an iterative process of "responsive" evaluation (Abma & Stake, 2001; Youker, 2005). "Responsive" means here that what is happening in classrooms is important and the focus lies on the pedagogical and learning fit and value. Therefore, the metrics employ an evaluation methodology of a mixed nature (qualitatively/quantitatively) and special care is given to make it manageable in a school context (without disturbing too much the daily lessons).

The metrics will provide "responsive" feedback from the users, teachers and students, concerning the iMuSciCA's STEAM pedagogy, upon which we can improve further the iMuSciCA's pedagogy, workbench, scenarios and lesson plans.

Please note that these improvements are also the principal aim of the evaluation methodology, which on the other hand does not make any claim to prove that the iMuSciCA's pedagogy works better compared to other, more classical pedagogies; for this reason no control groups will be used.

In order to reach the desired results, the iMuSciCA evaluation will focus on the students' achievement of deeper learning competencies. The metrics were therefore developed taking this into consideration. Deeper learning was chosen because it is opposed to superficial or 'thin' learning (Jensen, E., & Nickelsen, L., 2008). In particular iMuSciCA uses the framework proposed by the Hewlett Foundation on deeper learning (https://www.hewlett.org/programs/education/).

In view of the iMuSciCA evaluation methodology, the Hewlett Foundation competencies are classified in the following three groups:

Part A: Cognitive competencies
- (1) Mastering rigorous academic content
- (2) Thinking critically

Part B: Interpersonal competencies
- (3) Working collaboratively
- (4) Communicating effectively

Part C: Intrapersonal competencies
- (5) Learning to learn
- (6) Developing academic mindsets

	Cognitive (thinking and reasoning)	Interpersonal (expressing information to others and interpreting others)	Intrapersonal (self-management to reach goals)
Deeper Learning Competencies	Thinking critically	Working collaboratively	Learning to learn
	Mastering rigorous academic content	Communicating effectively	Developing academic mindsets

Figure 1. Classification of Deeper Learning competencies as used by iMuSciCA (adapted, based on National Research Council)

iMuSciCA focusses on a selection of outcomes for each of these competences, which were identified in the previous deliverable *D2.2 - Initial Evaluation Metrics for Deeper Learning With iMuSciCA*. Indeed, the outcomes specified by the Hewlett Foundation refer to what "graduate students from high school should be equipped to". iMuSciCA however does not deal with graduates, but with younger students (from 10 up to 18 years old students). For this reason not all, but a selection of the given outcomes will be assessed in iMuSciCA.

2.2. Implementation of the evaluation

The aim of the evaluation is to show how the iMuSciCA STEAM pedagogy supported by the iMuSciCA workbench can improve the practice in class and will focus on:

1. The pedagogical and learning fit and value.
2. Technical usability and acceptance in view of the pedagogical and learning value.

The evaluation is collecting various 'responsive' observations and feedback from the practitioners, teachers and students, both pedagogical ones as some tracking data, with the aim to improve iMuSciCA's workbench and scenarios. iMuSciCA's piloting is primarily about improvement of the practice in class and is not to be confused with a large scale study proving that some methodology is better than another one. Though some additional feedback might be collected in classes with only light implementation of iMuSciCA (only a few hours), iMuSciCA's evaluation and the conclusion thereafter will be based, in line with the *D6.1- Pilot Testing Action Plan*, on schools with in depth implementation of iMuSciCA: this means 8 lesson hours of iMuscica or more. This implies that all inquiry phases will be used, that there will be extensive use of tools, reflection, dialogue and interactions as foreseen in iMuSciCA's pedagogical framework. Only in those cases evaluation of iMuSciCA's STEAM education pedagogy makes sense (see also D 6.1).

We give an overview of iMuSciCA's evaluation implementation that bring in place a combinational qualitative/quantitative analysis methodology. It is based on *D2.2 - Initial Evaluation Metrics for Deeper Learning With iMuSciCA* and *D6.1 - Pilot Testing Action Plan*.

The evaluation consists out of collecting:

Real reactions of teachers and students: qualitative input

- Observations
- Focus groups

The developed metrics of deeper learning will give outermost attention to the real reactions of the teachers and students themselves, as given in authentic class observations, observations of students activities as well as experiences reported during interviews or focus groups.

Questionnaires: quantitative input

- Students Questionnaire
- Teacher Questionnaire

The qualitative inputs are supplemented by questionnaires, especially where 'core content', 'critical thinking and problem solving' and 'develop academic mindsets' are concerned.

Tracking learner's activity

iMuSciCA's Biometric recordings will be implemented in iMuSciCA's in depth implementation schools. Due to various boundary conditions of constancy, limited equipment and time, they can only be implemented in a "lab environment", i.e. one student at a time in a separate room. This information will be cross-analysed in relation to the collected pedagogical feedback. The tracking information consists of:

a) The events recorded by the iMuSciCA Workbench
b) The biometric data (Advanced Learner Monitoring Mechanisms like Eye Tracking, Brain Imaging (EEG), Galvanic Skin Response (GSR), Facial Expression Analysis etc.) collected while using the tools of the workbench in heavy implementation schools.

In order to make sense out of the tracking information, the biometric data will be analysed *in combination* with the input from teachers and students in order to optimize both the technical and pedagogical usability. We give two examples of such a combined analysis:

i) Solving issues with user friendliness.
   For instance, if the interface is found to be too difficult in the sense that the user has to click on many items or menus in order to find his or her way through the tool, biometrical data like eye tracking will be analysed in combination with recorded events and observational data in order to identify problematic design issues.
ii) Solving issues linked with some competence of the deeper learning.
   If there might be a problem of motivation or frustration while working with the workbench, and this is observed in pedagogical settings, this can be further analysed by cross-checking it with biometrical data like facial expression analysis, galvanic skin response and the like, that can possibly be linked to the emotional state of the learner.

Biometrical data will be collected as follows:

Eye tracking record the eye gaze with the respective fixations on the respondents stimuli screen as well as the dilation and constriction of the pupils, which has been found to correlate with emotional arousal and cognitive workload. Eye tracking therefore can be used to validate and complement GSR measurements.

Facial expression analysis is a non-intrusive method to assess both emotions (subtle movements in face muscles, mostly subconscious) and feelings (accompanied by clearly noticeable changes in facial expression). While facial expressions can measure the valence of an emotion/feeling, they can't measure the associated arousal but this can be linked possibly with the pedagogical observations.

Electrodermal activity (EDA), also referred to as **galvanic skin response (GSR)**, reflects the amount of sweat secretion from sweat glands in our skin. Increased sweating results in higher skin conductivity. When exposed to emotional stimulation, we "sweat emotionally" – particularly on forehead, hands, and feet.

Electroencephalography (EEG) analyzes brain dynamics of engagement (arousal), motivation, frustration, cognitive workload and other metrics associated with stimulus processing, action preparation, and execution. EEG tracks stimulus-related processes much faster compared to other biometrics sensors, but it's a rather noisy source of information affected by several natural actions of participants such as their movements of head, muscles, eye blinking, etc.

2.3. Result of the evaluation

The outcome of the evaluation metrics will be **concrete suggestions to improve** the usability, pedagogical and learning fit. The format of the evaluation metrics allows working without long lists of criteria, which are not easy to handle in a pedagogical school context. Such long lists tend to give teachers (and also researchers!) a lot of information but not necessarily the adequate insights on 'what to improve' in the pedagogy or in the tools. Indeed, the focus of this assessment is to improve iMuSciCA, improve the adopted STEAM pedagogy and optimize the workbench, the lesson plans and scenarios that support teachers in using the iMuSciCA tools. For this reason, this assessment is part of an iteration process where piloting and improvement alternate, with the aim of improving the STEAM pedagogy and its contribution to deeper learning. A long-time effectiveness study, with comparison to some other methodology or control group, is not foreseen in the project life-time, as this would require a much longer implementation time and a much larger study group.

3. The final metrics for the iMuSciCA evaluation

3.1. The metrics reflect the piloting methodology

The evaluation metrics described in this deliverable will be applied during piloting phase B in the so called 'heavy implementation schools'. These are the schools which will implement the iMuSciCA pedagogy and workbench for at least 8 school hours. Indeed, shorter implementation time would not be sufficient to observe any statistically significant result on deeper learning. The results of this evaluation will be at the base of the further optimization of the iMuSciCA learning environment.

The metrics were developed taking into account the real class situations in order not to disturb too much the daily lessons. The aim of the evaluation is to be 'responsive', to see if iMuSciCA can address deeper learning in a reasonable way as perceived by teachers and students and the metrics should provide detailed and valuable information on how to improve the iMuSciCA workbench and pedagogy.

3.2. Metrics for the iMuSciCA evaluation

For practical reasons the 6 main deeper learning competencies were grouped as described in Chapter 2, Figure 1 and the metrics were developed accordingly. Table 1 reports an overview of the evaluation tools developed for each of the three groups of competences: this is an adapted version compared to deliverable D2.2, which takes into account the new adaptations. All evaluation tools will be deployed for each scenario implemented in a class, but for Part C tools, which will be deployed before and after the implementation of a series of scenarios (lasting in total several lesson hours) in a class (pre- and post-questionnaire).

Deeper learning competencies promoted in iMuSciCA	**Observation**	**Student focus group** (small group) or **questionnaire** and **report of teacher feedback**	**Questionnaires** (to students and teachers)	**Human-Computer Interaction**
Part A: Cognitive competences ***(1) Mastering rigorous academic content*** ***(2) Thinking critically***	Do students **acquire** the **core concepts** intended in the scenarios? Can students **apply** the appropriate **tools** and **techniques for problem solving in** the different STEAM disciplines involved in iMuSciCA? *Based on a list of criteria to be evaluated on a Likert scale 1-5*	**Students reflect** on their learning of core concepts or the application of them in the different STEAM fields by looking at and commenting on their work. **Teachers** are asked to **comment** on the learning of their students. *Based on a list of criteria to be evaluated on a Likert scale 1-5 and a report of teachers feedback*	**Student Questions** around the **core concepts and** applying **core problem solving**. Students have to **explain their rationales.** **Question the teacher about this item**. *Based on self evaluation by students (Likert scale 1-5) compared with the results of a content test (Likert scale 1-5)*	**Answers to questions embedded in lesson plans** will be saved and reviewed by teachers and researchers. **Details about the use by pupils (choice, time they spent) of particular tools on the workbench** (provided by the iMuSciCA tracking system), in relation to specific activities in the lesson plans. *Results to be used as a comparison/reference tool in case of issues raised by other tools*
Part B: Interpersonal competencies ***(3) Working collaboratively***	**Students push each other** to explain their thinking and ideas. Can students work collaboratively with others to	**Students reflect** on the way they could: - work independently - used the complementary skills of every	**Question the teacher about this item.** *Based on a list of criteria to be evaluated on a Likert scale 1-5*	**Interactions between students; sharing of resources; information exchange.**

(4) Communicating effectively	complete tasks and solve problems? **Can students give** each other **constructive feedback**? Do they **listen to others' feedback and ideas**, and are they prepared to **incorporate it** in their thinking? *Based on a list of criteria to be evaluated on a Likert scale 1-5*	group member at the same time. **Students and teachers reflect** on the quality of the delivered work. *Based on a list of criteria to be evaluated on a Likert scale 1-5*		*Results to be used as a comparison/reference tool in case of issues raised by other tools*
Part C: Intrapersonal competencies ***(5) Learning to learn*** ***(6) Developing academic mindsets***	Do **students ask content-related questions** to themselves, to peers and teachers. **Students are motivated** to put in the time and effort needed to build a solid knowledge base and to accomplish important goals. *Based on a list of criteria to be evaluated on a Likert scale 1-5*	**Students reflecting** on their progress, using discussions with teachers and peers to keep up their own learning. **Students reflect** on their effort. *Based on a list of criteria to be evaluated on a Likert scale 1-5*	**Students' Questionnaire, self evaluation and motivation questionnaire** by students **compared** with the results of **teachers. Question the teacher about this item.** *Based on a list of criteria to be evaluated on a Likert scale 1-5*	Any communication between student and teacher, or amongst students via the **Moodle platform**. *Results to be used as a comparison/reference tool in case of issues raised by other tools*

Table 1. Scheme of the iMuSciCA evaluation methodology

The above metrics is concretized in a manageable way in the following evaluations tools, the templates of which can be found at the appendices.

Part A: Cognitive competencies

These tools will be implemented in each lesson focussing on one iMuSciCA scenario.

- One template per iMuSciCA scenario including: i) criteria for observation (by teacher or external observer), ii) guiding questions/criteria for focus group with students, iii) short summary report of teachers' feedback. You can find template of part A for a specific scenario, namely Scenario 2.1 (lower secondary) as an example in the appendices. Templates for other scenarios follow the same format.
- Students' questionnaires in the form of one test per scenario, also including short self evaluation on content knowledge, to be compared with each other. You can find here an example of questionnaire for a specific scenario, namely Scenario 2.1 (lower secondary) as an example in the appendices. Questionnaires for other scenarios follow the same format.

Part B: Interpersonal competencies

This template will be applied in each lesson focussing on one iMuSciCA scenario. You will find it in the appendices.

- Template includes: i) criteria for observation (by teacher or external observer), ii) guiding questions/criteria for focus group with students, iii) short summary report of teachers' feedback and iv) students' reflection questionnaire. The questions to the student and the observer are very similar in order to make comparison possible. This questionnaire is the same for all scenarios.

Part C: Intrapersonal competencies

This template will be applied as a pre- and post- questionnaire, before and after implementing a series of scenarios in a specific class. You will find it in the appendices.

- Template including: i) criteria for observation (by teacher or external observer) ii) guiding questions/criteria for focus group with students, iii) short summary report of teachers' feedback iv) students' reflection questionnaire and v) students' motivation questionnaires. The latter questionnaire is based on the 'Measurement of Motivation with Science Students' (Mubeen, S., & Reid, N., 2014).

All templates can be found at the given URLs and in the corresponding appendices at the end of the document. Of course the templates to be used by students are partially adapted according to the age category, therefore, for some of the templates there will be two adapted versions: one for lower secondary and one for upper secondary students.

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Appendices

Appendix 1:
Assessment of Deeper Learning Competencies Part A

iMuSciCA
Assessment of Deeper Learning Competencies Part A

Criteria for observation (by teacher or external observer)
Guiding questions/criteria for student focus group
Summary of observation and student focus group

Deeper Learning Competencies part A

(1) Mastering rigorous academic content
(2) Thinking critically

Scenario 2.1

Concepts

- The students can produce different tones on an instrument without changing anything on the instrument itself.
- The students can explain that the formed natural tones always have a fixed pitch and frequency. The frequencies of the produced natural tones on chordophones and aerophones are in principle integer multiples of the frequency of the fundamental.
- The students can produce natural tones on different instruments.
- The students can explain the concepts of natural tones and how the frequencies of them are mathematically related.
- The students can play a melody with natural tones.

1. Observation by observer / class teacher (circle what applies)

	Criteria	**Strongly Disagree**				**Strongly Agree**
1	The students can produce different tones on an instrument without changing anything on the instrument itself.	1	2	3	4	5
2	The students can explain that the frequencies of the produced tones are always an integer multiple of the frequency of the fundamental.	1	2	3	4	5
3	The students can explain why on an instrument (without changing anything), no other tones can be produced than the natural tones.	1	2	3	4	5
4	The students can explain the concepts of the fundamental and natural tones.	1	2	3	4	5
5	The students can play a melody consisting out of natural tones only.	1	2	3	4	5
6	The students understand the concepts and relationships within the theme and organize this information.	1	2	3	4	5
7	The students can explain the most important concepts in their own words.	1	2	3	4	5
8	The students formulate problems and generate hypotheses.	1	2	3	4	5
9	The students evaluate, integrate and critically analyse multiple sources of information.	1	2	3	4	5

2. Guiding questions for students' focus group

	These questions can help the teacher or observer who leads the focus group with the students. *Tick 'Bad' if your observations was that the students cannot answer properly these questions. Tick 'Good' if the students could answer these questions.*	**Bad**				**Good**
1	Explain what tones you hear when you play a whirly tube?	1	2	3	4	5
2	Is there a mathematical relation between the frequencies of the natural tones?	1	2	3	4	5
3	Can you produce other tones, besides the natural ones (without changing the instrument)?	1	2	3	4	5
4	What is a fundamental and natural tone?	1	2	3	4	5
5	Have students understood the content of the today's lesson?	1	2	3	4	5

6	Were the instructions for today's lesson clear enough?	1	2	3	4	5
7	Was it easy to perform the foreseen activities? Have you been facing difficulties?	1	2	3	4	5
8	Where you able to solve the problems posed in the lesson?	1	2	3	4	5
9	Were the tools of iMuSciCA helpful to perform the activities?	1	2	3	4	5

Summary of observation and student focus group

Appendix 2:
Questionnaire for students competences Part A

Test for students about 2.1 Sequence of Natural Tones

Agreements

- The test is corrected in the classroom.
- You work individually and get 20 minutes to complete this test.
- The purpose of this test is to check whether you understand the concepts of this lesson.

Materials

- Test
- Writing materials

Goals

- The students can explain that the formed tones always have a specific frequency. These frequencies are always integer multiples of the frequency of the fundamental tone.
- The pupils can explain the concepts of the fundamental tone and the natural tones.

	Name: _____Modelsolution _____ Class: _____ Date: _____ Teacher: _____ Score: ____ / 10

Test about 2.1 Sequence of Natural Tones

Self-evaluation by student

For the student	*Disagree -> Agree*				
I understood the study material during class.	1	2	3	4	5
I could easily solve the theoretical questions.	1	2	3	4	5
I could easily solve the exercises.	1	2	3	4	5
Which score do you expect?	___ / 10				

Actual Test

1) Are the following statements true or false?

Correct if false. (__ / 2)

(Write an 'X' in the corresponding square, correct false answers on the dots.)

	Statement	True	False
1)	You can play any tone you want on an instrument without changing anything (so no changes in length, do not open or shut holes...). Without changing anything on the instrument you can only play a certain set of tones: the natural ones. To produce other tones you have to change the border conditions of the instrument like making it longer or shorter, changing the tension of strings etc.		X
2)	The first natural tone is also called the fundamental tone..	X	

2) Solve the exercises below. (__ / 8)

a. The frequencies of the first two natural tones of a chordophone have already been filled in. Complete the table. (__ / 4)

n	f (Hz)	Difference (Hz)
1	120	-
2	240	120
3	360	120
4	480	120
5	600	120

b. Write down the frequency of the 12th harmonic of this instrument. Write out the calculation you made. (__ / 2)

___120 Hz . 12 = 1.440 Hz => 1.440Hz_____

c. The third harmonic of another chordophone has a frequency of 99Hz. What's the fundamental frequency of this instrument? Write out the calculation you made. (__ / 2)

___99 Hz / 3 = 33 Hz => 33Hz_____

GOOD LUCK!

Appendix 3:

Assessment of Deeper Learning Competencies Part B

iMuSciCA

Assessment of Deeper Learning Competencies Part B

Criteria for observation (by teacher or external observer)

Guiding questions/criteria for student focus group

Summary of observation and student focus group

Student reflection questionnaire

Deeper Learning Competencies part B

(3) Working collaboratively

(4) Communicating effectively

Evaluated goals

- Students can collaborate with others.
- Students can communicate clearly and effectively.

1. Evaluation by observer / by class teacher (circle what applies)

	Criteria	**Strongly Disagree**				**Strongly Agree**
1	Students provide each other with constructive feedback.	1	2	3	4	5
2	Students are willing to listen to each other's feedback.	1	2	3	4	5
3	Students are willing to incorporate each other's feedback in their own thinking.	1	2	3	4	5
4	Students are part of a team. This means that they actively participate though they realise they don't have to do everything themselves.	1	2	3	4	5
5	Students share and distribute tasks in view of adequate problem-solving.	1	2	3	4	5
6	The teams work individually.	1	2	3	4	5

2. Guiding questions for students' focus group

	These questions can help the teacher or observer who leads the focus group with the students. *Tick 'Bad' if your observations was that the students cannot answer properly these questions. Tick 'Good' if the students could answer these questions.*	**Bad**				**Good**
1	How was the interaction with the teacher(s)?	1	2	3	4	5
2	How was the collaboration with the other students?	1	2	3	4	5
3	Have you received enough support when needed e.g. from the teacher(s), from other students?	1	2	3	4	5

Summary of observation and student focus group

3. Student reflection questionnaire

	Criteria	**Strongly Disagree**				**Strongly Agree**
1	I provide my team members with constructive feedback.	1	2	3	4	5
2	My team members provide constructive feedback.	1	2	3	4	5
3	I am willing to incorporate someone else's feedback into my own way of thinking.	1	2	3	4	5
4	I am part of the team. This means I cooperate actively, but also do not want to do everything alone.	1	2	3	4	5
5	My team members and I share and distribute tasks in view of adequate problem-solving.	1	2	3	4	5
6	My team works individually.	1	2	3	4	5
7	My team has achieved good results through teamwork.	1	2	3	4	5

Appendix 4:

Assessment of Deeper Learning Competencies Part C

iMuSciCA

Assessment of Deeper Learning Competencies Part C

Criteria for observation (by teacher or external observer)

Guiding questions/criteria for student focus group

Summary of observation and student focus group

Self-evaluation by the student about the iMuSciCA classes

Deeper Learning Competencies part C

(5) Learning to learn

(6) Developing academic mindset

Evaluated goals

- Students learn how to learn
- Students develop an academic mindset

1. Evaluation by observer / by class teacher (circle what apply)

	Criteria	**Strongly Disagree**				**Strongly Agree**
1	The students ask themselves questions about the content.	1	2	3	4	5
2	The students try solving a problem in group first before asking the teacher for help.	1	2	3	4	5
3	The students easily refocus after distractions and maintain momentum until they reach their goal.	1	2	3	4	5
4	The students care about the quality of their work and put in extra effort to complete the exercise thoroughly and accurately.	1	2	3	4	5
5	The students show interest.	1	2	3	4	5
6	The students notice that the iMuSciCa lessons continue to build upon what they already know.	1	2	3	4	5
7	The students understand the work they do now will benefit their future life.	1	2	3	4	5

2. Guiding questions for students' focus group

1	What did you like about the session?
2	What did you find less interesting about this session? Why?
3	What do you propose to make it more interesting?

Summary of observation and student focus group

3. Self-evaluation by the student about the iMuSciCA classes

You will be asked to express your agreement on each statement. There are no 'right ' or `wrong' answers. We just want your opinion.

Draw a circle around:
1. if you strongly disagree
2. if you disagree
3. if you have no opinion
4. if you agree
5. if you strongly agree

Some statements in this questionnaire are fairly similar. Don't worry about this. Simply give your opinion about all statements.

	Criteria	**Strongly Disagree**				**Strongly Agree**
1	I reflect about the subject.	1	2	3	4	5
2	We try solving a problem in group first before asking the teacher for help.	1	2	3	4	5
3	I can easily refocus after distractions and concentrate on my goal.	1	2	3	4	5
4	I care about the result and put in extra effort to accurately execute the exercise.	1	2	3	4	5
5	I understand the importance of school for my life and interests.	1	2	3	4	5
6	I see that the iMuSciCA lessons continue to build upon what I already know.	1	2	3	4	5
7	I see the work I do now will benefit my future life.	1	2	3	4	5

Students' Motivation Questionnaire[1]

		Strongly Disagree				Strongly Agree
1	I take pleasure in science learning.	1	2	3	4	5
2	My personal goals and objectives are in line with my science learning.	1	2	3	4	5
3	It always concerns me that other students perform better in science.	1	2	3	4	5
4	I'm anxious about how I will perform at the science exam.	1	2	3	4	5
5	Even if learning science is difficult, I try to understand.	1	2	3	4	5
6	I become anxious when a science test approaches.	1	2	3	4	5
7	It is essential and valuable for me to get high scores on science.	1	2	3	4	5
8	I learn science with great interest and put in adequate effort.	1	2	3	4	5
9	I employ different approaches that ensure I learn the science well.	1	2	3	4	5
10	The science I learn can assist me to find an excellent career.	1	2	3	4	5
11	I think about the science learning and how it will help me in my profession.	1	2	3	4	5
12	I expect to achieve better results in the science subjects than other students	1	2	3	4	5

[1] Student's Motivations Questionnaire is based on Mubeen, S., & Reid, N. (2014). The Measurement of Motivation with Science Students. *European Journal of Educational Research*, *3*(3), 129-144.

		Strongly Disagree				Strongly Agree
13	It makes me worried to think about a weak performance in the science exam.	1	2	3	4	5
14	I try to outperform the other students during science evaluation.	1	2	3	4	5
15	I take my science performance seriously and how it will influence my overall grade.	1	2	3	4	5
16	Receiving high grades in science is not as significant to me as the science I learn.	1	2	3	4	5
17	I think science will be considerably helpful or useful to me.	1	2	3	4	5
18	I do not like to even think about science evaluation.	1	2	3	4	5
19	How I will employ the science which I study in daily life and in future is significant to me.	1	2	3	4	5
20	I am personally responsible if I do not get the science well and am weak in understanding	1	2	3	4	5
21	I am sure to perform better in science projects or developments and labs.	1	2	3	4	5
22	I find studying science interesting.	1	2	3	4	5
23	Science has value for me.	1	2	3	4	5
24	I am confident in my abilities to perform well in science exam.	1	2	3	4	5
25	All the science learning is pertinent to my life.	1	2	3	4	5

		Strongly Disagree				Strongly Agree
26	I accurately prepare science tests and laboratory work.	1	2	3	4	5
27	When I learn science I like that it challenges me.	1	2	3	4	5
28	I am sure about my capabilities and competencies in the science subject.	1	2	3	4	5
29	I am positive that I can achieve high grades in science subjects.	1	2	3	4	5
30	I successfully understand science.	1	2	3	4	5