PROJECT TITLE: **Mathematics of the Future: Understanding and Application of Mathematics with the help of Technology**

Intellectual Output 2:   **Development on the new teaching methodology and technology**

Programme: Erasmus+
Key Action: Cooperation for innovation and the exchange of good practices
Action Type: Strategic Partnerships for higher education
Ref. No.:   2020-1-RS01-KA203-065388

Results   2.2   **Guidelines for on line material in the STEAM context**

Authors:

  Mirjana Mikalački, Rale Nikolić, from **UNS, BMU**

Guidelines for preparing online material in the STEAM context through Moodle platform

Contributor: University of Novi Sad

Intended users
Teaching staff at the higher education institution or high schools who are involved in teaching material preparation using STEAM methodologies and modern technologies in teaching.

Platform used
The platform chosen for the development of the online courses is Moodle, as a widely used learning platform with lots of embedded tools and support. Moodle is an open source software that has been used at the Faculty of Sciences at University of Novi Sad for many years. It is developed continuously, and new features are embedded into the system to enable both combined learning as well as completely online courses. Moodle can be easily extended, adapted, and modified to satisfy different needs, and it comes in 120 different languages, so it can be localized to specific country and region.

Guidelines
Preparing a course in the STEAM context requires putting everything in the wider perspective and connecting the knowledge with different areas. Therefore, the plethora of possibilities that Moodle offers enables the creation of such courses. First, the video material is supported, which undoubtedly eases the following of the whole teaching process that goes online. Secondly, the support is provided for different activities that leads towards implementation of STEAM methodology in teaching.
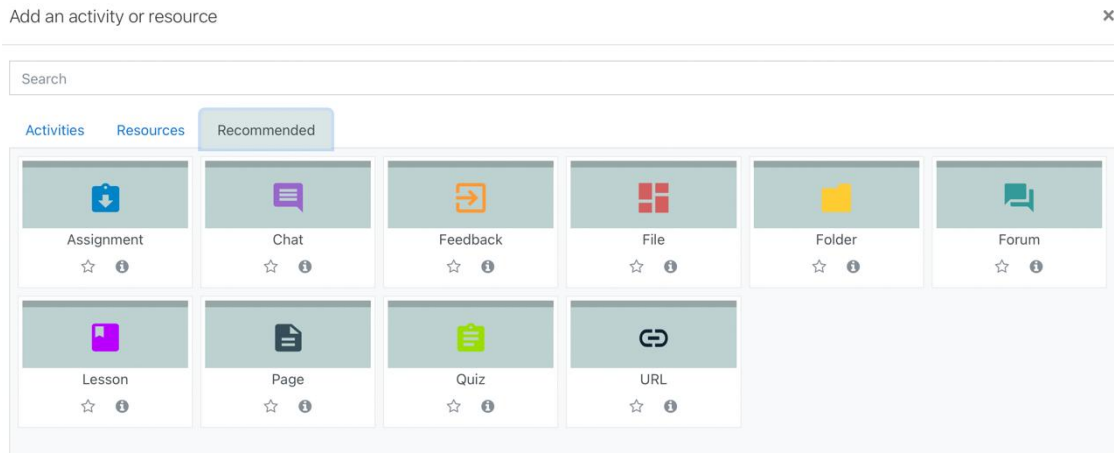
Figure 1. Recommended activities

Activities

As mentioned previously, various activities can be added to an online (or partly online) course on Moodle. Several of them will be described in this guideline.

Lesson

To start with, we will describe a lesson: this is what resembles a standard lesson from a course book, but is digital and navigated, so it can be easily followed. At the beginning, a teacher defines the format of the lesson, the title and content, as well as the set of questions that will follow the content of the lesson. A lesson consists of multiple pages and optionally some content pages. A page usually consists of some text and ends with one or more questions. The text can be complemented with different multimedia content (videos, images, sound, hyperlinks, etc.). Each answer to the question contains a link (so-called jump) that can be absolute (specifying a particular page in the lesson) or relative (this page or next page). Also, the navigation buttons can be added to the lesson, so a student can navigate through lesson in predefined way, and if teacher made it possible return to the unseen questions or previous content. That all can be defined through the content pages. So, a lesson contains a part of the course where the essential theoretical knowledge lies, but also some useful questions and relations to the applications of the theory. Coming back to the STEAM context, a lesson should be organized in such a way that combines theory with the examples in various areas, i.e., that relates the content to life problems. Moreover, a STEAM lesson should integrate contents from arts as well, so it means application as well as demonstration of the obtained skills. Moodle's lesson maker enables all of this by creatively using page contents and additional specific content pages.

Quiz

A good way of testing the knowledge is through quizzes. First of all, a quiz can be set up in various ways, depending on what type of knowledge test it should be:

it can be a test that a student can take several times, basically to serve for practicing some skills or knowledge, or

it can be a test of knowledge that is graded, limited by time and no repetitions are allowed, or a question can be viewed only once, without a possibility of coming back to the question (sequential navigation), see Figure 3 and Figure 4.

Teacher can also define the format of the answers and the time of their appearance (during test, after test, etc.). Essentially, the most important is to know the type of test that is going to be conducted, and what type of questions is best suited for the needs.

Figure 3. General info about the quiz and timing   Figure 4. Layout and other options

The next thing, a teacher should think about is the structure of the quiz: which type of questions and the number of them to be set for the quiz.
As for the different question types, Moodle allows 17 types of questions to be chosen from (10 of them can be seen in Figure 5, and the rest in Figure 6). Each question type has a detailed description, so one can easily recognize which question type is suitable for the planned knowledge test.
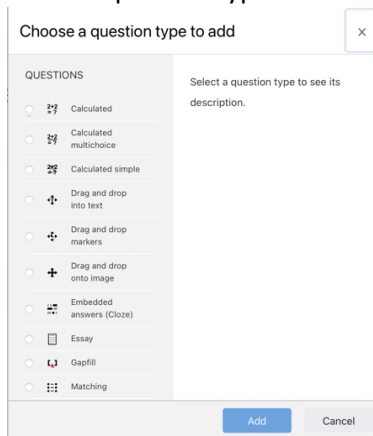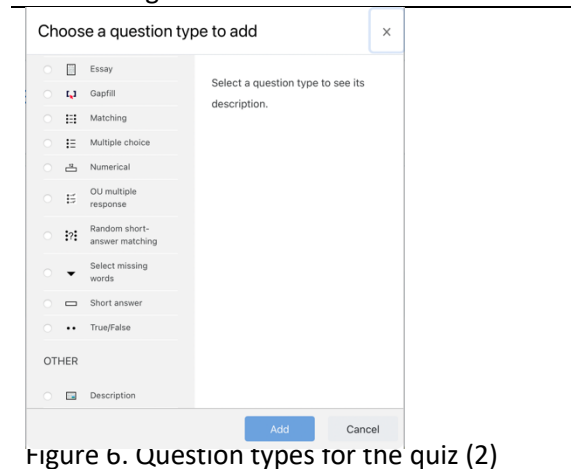

Figure 5. Question types for the quiz (1)   Figure 6. Question types for the quiz (2)

An example
We give an example of how a test can be made on Moodle platform using STEAM methodology.
Suppose we have the following test:

Co-funded by the
Erasmus+ Programme
of the European Union

Test

The function F, is given as $F(t) = \int_{-2}^{t} f(x)dx$, where f is function defined and continuous on interval $[-2,8]$.
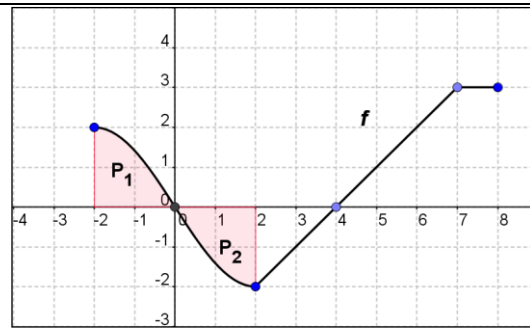The function f is given with its graph shown in Figure. It holds $P_1 = P_2 = 2.5$.

Figure 1.

1. Fulfill the following table

t	-2	-1	1	1	2	3	4	6	7	8
$F(t)$										

2. Determine the domain of F.
3. Determine the range of F.
4. Determine the intervals where the function F increases. Determine the intervals where the function F decreases.
5. Determine the values of t in which the F has local minimum and local maximum.
6. Determine the intervals where the function F is convex. Determine the intervals where the function F is concave.
7. Determine the sadle points of the function F.
8. Connect the functions f and F?
9. Draw the points $(t, F(t))$, and sketch the graph of F.
10. Determine:
   a) $\int_0^2 f(x)dx, \int_{-2}^2 f(x)dx, \int_2^4 f(x)dx, \int_2^5 f(x)dx, \int_7^8 f(x)dx$,
      (the function f is given by its graph in Figure 1).

We'll show how to create first two questions. For each question, we can choose an appropriate type of question (as shown in **Error! Reference source not found.** and Figure 6). Let us start with the first question. The student should fill in the given table, therefore the most appropriate type would be "gap fill" type of question. So, we can create a table with gaps (denoted by ## in Figure 7). In between the ## we simply add the answers, which won't be visible to students, but the system will know how to grade them. Note that we can also add some distractors to this type of question, that is used when, for example dragdrop option is selected (Figure 8), so a system can offer additional answers that are not correct but are there to distract students. We can also create something called information that need not be a question (and is actually serving as a label) but gives additional information to the question. This is done for the question 1, where in information type of question (see the last option in Figure 6), we added the information about the function F together with its graph.

Figure 7. Gap fill type of question

Figure 8.Additional options for gap fill type of question

When everything is set, we have a question that appears like the one shown in Figure 9.

The function F is given as $F(t) = \int_{-2}^{t} f(x)dx$, where f is function defined and continuous on interval [-2, 8].

The function f is given with its graph shown in Figure. It holds $P\_1 = P\_2 = 2.5$

Fill in the following table

t	-2	-1	1	1	2	3	4	6	7	8
$F(t)$										

Figure 9. Test: question 1 (preview)

For the second question, we can choose "short answer" type of question (Figure 6). There we can specify which answers we accept and to which extent (50%, 100%, etc.). After adjusting all we need, we can obtain the question that looks like the one shown in Figure 10.
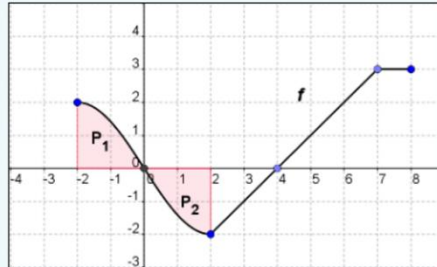
Question **2**

Not yet answered

Marked out of 1.00

⚑ Flag question

⚙ Edit question

The function F is given as $F(t) = \int_{-2}^{t} f(x)dx$, where f is function defined and continuous on interval [-2, 8].

The function f is given with its graph shown in Figure. It holds P_1 = P_2 = 2.5

Determine the domain of F.

Answer:

Previous page   Finish attempt ...

Figure 10. Test: question 2 (preview)

For implementing a course based on STEAM methodology, activities such as chat (see Figure 1) or forum to enable discussions, are also available. There, students (as well as teachers) can exchange opinions on various topics and combine knowledge from different areas into one broad and diverse outcome.
Continuing in this manner, video materials, additional files and links can be added as well (see Figure 1).
These all support all types of courses and help in creating 100% online as well as combined courses.

Guidelines for on line material in the STEAM context

Contributor: Belgrade Metropolitan University

Intended users
Teaching staff at the higher education institution who are involved in teaching material preparation, and other stakeholders interested in introducing STEAM methodologies and modern technologies in teaching.
Methodology
The FutureMath project's aim is to implement innovative STEAM methods in teaching Calculus topics, and also to explore these different methodologies and their testing in pilot courses, conducted during the project.
Testing approach
Lesson plans are developed. Each lesson plan contains (Learning objectives, Aim of the lecture /

Description of the practical problem, Previous knowledge assumed, Introduction / Theoretical basics, Action, Materials / equipment / digital tools / software, Consolidation). The first exemplary lessons are planned to be used as preparatory lessons for future developments of other calculus related topics.

Online content. Lessons are built on the practical problems and projects assigned to students (based on problem-based or project-based learning methods), closely related to calculus topics. The online content is made to engage students and be more motivated in their learning. Each lesson contains lesson plan, lesson content (in both written and video formats).

Integrating developed STEM calculus lessons in the existing curriculum. Each lesson is integrated with existing teaching material and course curriculum, during the pilot phase of the project.

Encompassing online lessons with students. Developed lessons are assigned to students, and their progress and learning outcomes are carefully observed, in order to address any potential issues or needed future improvements.

Assessment. Each lesson contains assessment, designed to assess students' learning outcome. Assessment are in different formats: quizzes, tests, discussion, self-reflection.

Requirements for online platforms

As the consortium members are using different platforms and learning management systems to share the teaching content for their students, this section addresses specific requirements for each platform.

FutureMath project not only developed learning content to be implemented and shared with students at each institution, but developed lessons to be shared on project website, as a tool to facilitate and enable future development of STEAM calculus lessons and mathematics related topics.

Institutional requirements

Belgrade Metropolitan University

Belgrade Metropolitan University for its institutional learning system uses Learning Activity Management System (LAMS). To ensure that a broad range of learning activities and assessments can be used in online setting, LAMS implements a range of front-end features such as assignment submission, discussion forums, chat, notice board, online quizzes, Q&A, embedded videos, etc.

Online content needs to be developed in learning object (LO) format, where each LO is developed as a small modular unit, with the given learning outcome. Online content follows designed lesson plans, and contains:

Learning objectives,

Previous knowledge assumed,

Description of the practical problem,

Student project or problem assignment,

Theoretical basics,

Lesson video,

Activating exercises,

Discussion,

Self-evaluation with feedback

Assessment

Student homework assignment.

Two types of videos (clips) are recommended.

Introduction to the lesson: Recommended duration is 3 to 5 minutes. Introduction video clip introduces students to lesson objectives and learning outcomes, main teaching topics, and gives motivation for this topic in the context of the real world problem.

Lecture: It is recommended to take one video for about 10 minutes for each topic. The alternative is to divide topic and activities in several smaller videos. The aim of these videos is to provide the student with the core of the new concepts presented in the lecture, in addition to the rest of the teaching materials offered through LAMS.

Why 10 minutes?

Researchers' have shown that students lose attention when videos last longer than 10 minutes, and recommend 10 to 12 minutes as an optimum. Of course, if the teacher thinks that it is better to divide the content into several parts, he/she can record several video clips.

Video quality

Our goal is to make the video as professional as possible. It is best that the recording takes place in studio conditions, proper lights and microphone settings. The teacher can also do this using the camera on his computer and at home, but then the teacher must pay attention to the lighting, the volume and quality of the sound, and other factors that affect the quality of the recording.

What should the video show?

In the case of a lecture, it is usually a PPT presentation, and in the corner, a video of a teacher commenting on PPT slides. It is important that the teacher speaks clearly and loudly, that the teacher has a prepared concept of the presentation (it is harder to speak briefly and clearly). It should be noted that the teacher should not read the material, because then it is monotonous, without dynamics and students lose attention. The following are specific instructions on how to implement video recording.

Recording guidelines

In order for the whole process to begin, the appropriate hardware should be used. If it is a desktop PC, a suitable webcam (of at least 1 megapixel, because less than that does not give good enough image quality) and a microphone must be provided. If one works on a laptop, there is typically an integrated webcam and microphone, but one should check their quality, as they may not be good enough.

The following are tips on what needs to be provided in order for the recorded video to be of high quality and acceptable for publication by students.

- Recommended video resolution is 1920x1080 (or at least 1280x720 as the lower limit)
- MP4 video format (i.e. video output format recorded through Zoom web service)
- Pay attention to the audio recording, it is desirable to use an external microphone because of the sound quality itself.
- It is obligatory for the camera to be placed horizontally.

- The background itself needs to be neutral without unnecessary details (preferably white, gray)
- If an external camera or telephone is used, it is necessary for them to be on a tripod.
- Each video must start with a minimum of 5 seconds of still image, also a minimum of 5 seconds of still image at the end of the video.
 - Check that the focus is set correctly, as videos that are not in focus will not be accepted.
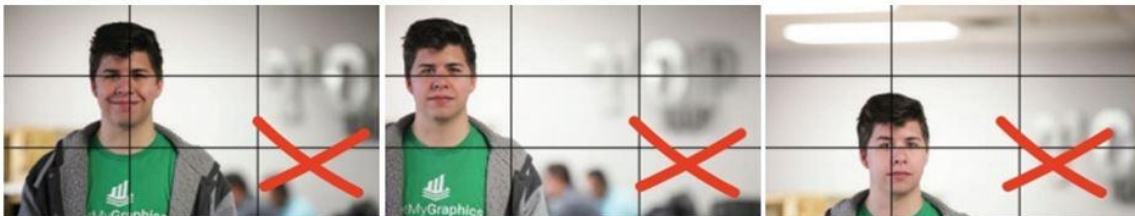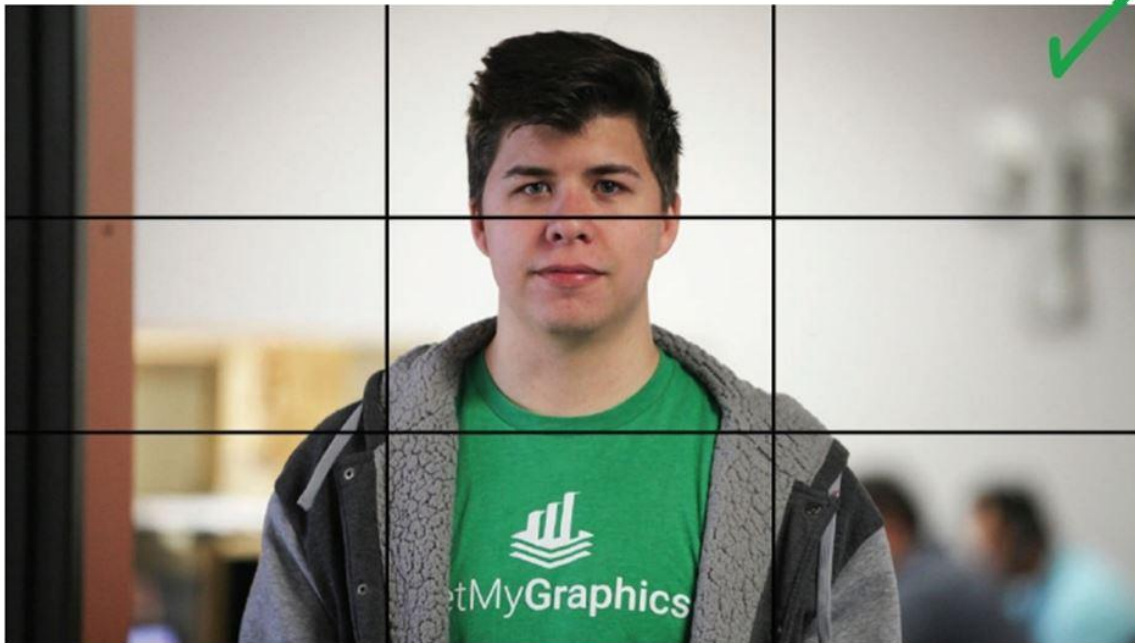
Light adjustment - basic instructions
Natural or artificial light: choose one. There are two types of light that one can choose as the main light source. One is natural light, which is used most often because it already exists! The other is artificial light that is created by flash or constant lighting. The main light or key light - it is the strongest and directly illuminates the object. It can be sunlight, studio flash, built-in flash, and the characteristic is that this is the strongest light in the photo. Supplemental light or fill light - dimmer light is used to remove unwanted shadows. Other lights - used to emphasize details. Our recommendation is that the key light be in front of the person or sideways from the person, never behind the person.
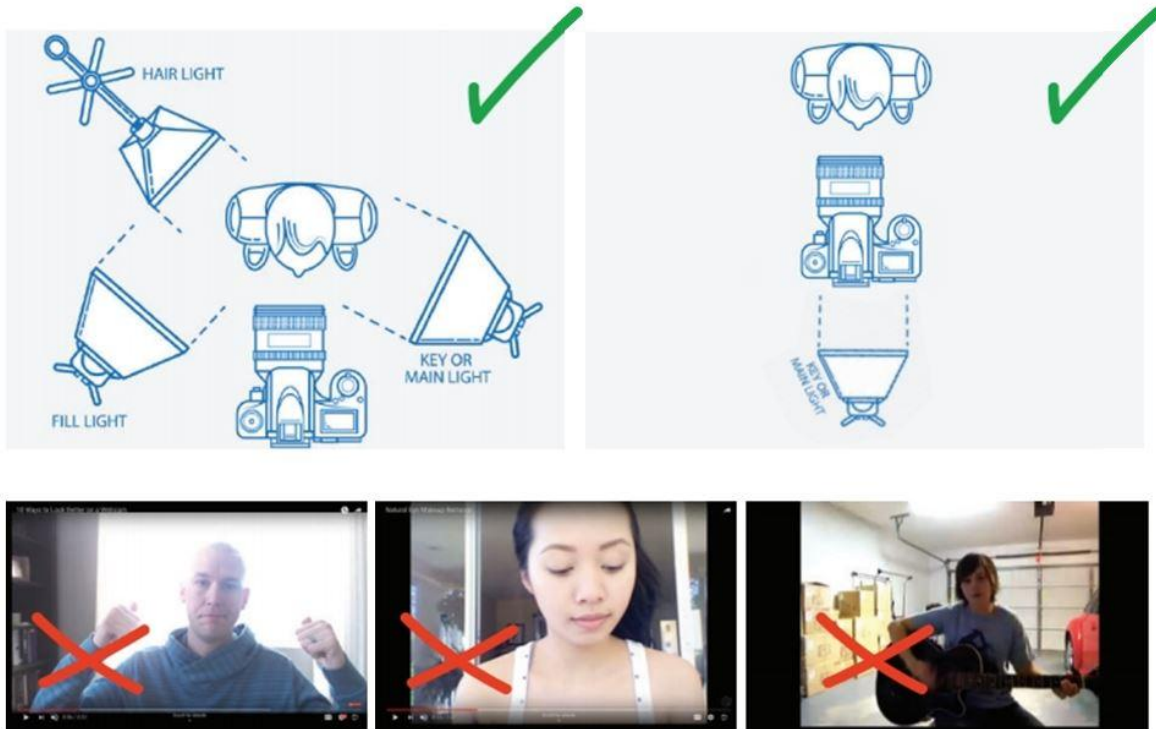
For the recording the video, different platforms can be used, but it is recommended to use Zoom platform, because of its simplicity and automatic generation of video in MP4 format. Zoom also allows for easy screen share, while showing the instructors video in the corner, as proposed by above recommendation.