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Guidelines for Evaluation of Inquiry-Based Mathematics at University Level

The PLATINUM Project

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Abstract

This document provides a detailed methodology for designing and evaluating Inquiry-Based Mathematics Evaluation in university education. In this sense, our objective is twofold: on the one hand, it must be useful for designing teaching activities coherent with Inquiry-based teaching, focusing in both the evaluation with respect to the learning and engagement of students and the evaluation of the design and implementation of the task itself. On the other hand, it helps lectures to develop schemes for learning outcomes and mathematical competence, as well as to monitor and assess students' engagement in Inquiry-based activities.

This methodology is composed of three stages: before, during, and after the inquiry. These stages include different subtasks that lecturers must follow in order to fulfil the objectives described above.

Finally, these guidelines are exemplified by a collection of experiences that illustrate how they can be used in different contexts. Lecturers can follow these examples when designing their own activities.

Keywords

University Mathematics Education, Evaluation in mathematics, Inquiry based learning, Inquiry based teaching.

Contents

1. Introduction

Our objective is to provide guidelines and recommendations which can be used as a collection of tools for measuring and evaluating Inquiry Based Mathematics Education (IBME) at university level. The target group are mathematics lecturers and educators working in higher education institutions.

Inquiry based learning exhibits a multi-faceted nature, can be presented in a variety of forms and be used for a wide range of activities of different, for example, difficulty level and time length during a Course or Unit. For these reasons we present a deep insight into IBME assessment which can be adapted to the different needs of lecturers in each case.

The guidelines and recommendations will enable lecturers to assess not only student's learning but also student's engagement with the learning and independently monitor the own teacher progress in mastering IBME.

It is clear that teaching activities or tools must be always designed and assessed to deal with their fields of application and scopes of the topic or subject involved, so any general guidelines must allow its appropriate transferability, this is, be easily adjusted and modified in accordance with the needs of individual lecturers.

The rest of the chapter is structured as follows: In Section 2, evaluation and measurement tools and criteria are presented, with an emphasis on the goals and stages of an IBME assessment process. In addition, both short and detailed guide for this process are provided. Next, Section 3 deals with a brief analysis of the assessment of each case of study, following the stages in the inquiry process as introduced in the previous section. We note that a complete description for each case as well as the detailed assessment process is given in the appendix. The chapter ends with a concluding section focus on the usability of this guide and its effectiveness.

2. Evaluation and Measurements Tools and Criteria

2.1. Goals and stages in IBME

To deal with our objective, in a first stage we analysed existing evaluation and measurement tools and criteria in inquiry based learning and identified those that could be used for:

With respect to students:

- Developing grading criteria and marking schemes for assessing students' mathematical competence in courses that include inquiry-oriented teaching-learning modules.
- Monitoring students' engagement (acting/learning) in IBME activities.

With respect to lecturers:

- Evaluating teaching with respect to the student conceptual learning of mathematics and their engagement in the process.
- Monitoring usefulness of tasks designed to introduce inquiry-based practices.

In a second stage we implemented the measurements tools and criteria. In turn, this involved:

- Systematic observation of tasks and analysis of data collected from diverse forms of activities.
- Iterative feedback into ongoing development: after testing, selection of appropriate instruments that enable teaching innovations including *Units and Course design* and *resources to monitor students work* on mathematical problems.

Finally, all the above processes were thoroughly documented and relevant practical guidelines and recommendations, with appropriate qualitative and quantitative indicators, were prepared.

Quality assessment in IBME environment must address both the evaluation of the whole inquiry process (this is, the product, the inquiry process and inquiry plan, the achievements of the proposed general objectives and specific goals) and the student's assessment. So, final guidelines and recommendations are intended to:

1. **Guide lecturers in IBME tasks**: Design of teaching activities coherent with IBME and evaluation of the own activities. This includes:
   - Evaluation of the IBME activities with respect to the conceptual learning of mathematics and engagement of students.
   - Evaluation of the design and implementation of the activities as tools for inquiry oriented teaching. By tool we must understand any pedagogical resource used to learn or teach.
2. **Guide lecturers in Student's assessment**:
   - Assess learning in IBME activities: Development of schemes for learning outcomes and grading criteria for assessing student's mathematical competence.
   - Monitor and assess student's engagement in IBME activities in terms of quality of the interaction between students and lecturers in terms of student's conceptual understanding.

To deal with this we propose following three main stages (which must be revised by lecturers cyclically following a feedback system) in all inquiry activity.

Stage 1, before the inquiry: As first stage of the process, lecturers have to:

- Set goals, objectives and tasks.
- Identify inquiry skills (pre and post activity).
- Set resources and formats.
- Design plans for the inquiry activity (sequence, timetable, questions); for retrieval information during the inquiry and for monitoring and assessment, both the students and the own activity.

Stage 2, during the inquiry: At a second stage, lecturers have to:

- Observe, collect and analyze information.
- Implement monitoring and assessment plans.

Stage 3, after the inquiry: At the last stage, lecturers have to carry out the:

- Student assessment, which must include criteria-based summative assessment and revision of formative assessment.
- Activity assessment as conclusions from the plan for reflecting, evaluating and revising.

2.2. Development of an IBME assessment process

The following sections present in detail the contents of each stage of the inquiry assessment process. The structure and contents presented in this section (and the Guideline) are based on the works of Cotton (1988), Alberta (2004) and Hanauer et al. (2009).

2.2.1. Begin the inquiry

The first stage for the assessment in IBME environment is devoted to setting goals, objectives and tasks. For evaluating an inquiry process and its results lecturers must have clearly established the objectives that they want to achieve and how (through what cognitive processes and what questions) they want to reach them.

Thus, this stage includes setting:

1. **Pedagogic case (onwards Unit) opportunities for IBME**. Four main topics have been identified:

   TOPIC 1: Within the program of studies of the Unit and the yearly plan, entry points and topics that engage student's interest and involve a problem issue.
   Aim: Setting objectives and learning outcomes of the Unit.
   Need to identify: Program of studies, course name (credits/hours); pedagogic case (topic; learning contents; aim); place of Unit in the course; mathematical concepts involved; expected learning outcomes.

TOPIC 2: Background knowledge and experience.
Aim: Identifying audience (homogeneity or heterogeneity of the group) and determine its prior knowledge and background experience in inquiry learning.
Need to identify: Learners profile (orientation, year, age); size of the group; prior knowledge; background experience in Inquiry.

TOPIC 3: Additional guidance.
Aim: Additional guidance for students so that they realize the task of the Unit and/or they can achieve successfully the learning outcomes.
Need to identify: Additional guidance if needed; special needs (if any).

TOPIC 4: Opportunities to engage all students.
Aim: Unit opportunities to engage all students in the class.
Need to identify: Opportunities to engage students (for highly motivated and those who require a lot of encouragement).

2. Scopes

Aim: Lecturers must describe clearly Intended Learning Scopes. Scopes must be formulated according the rules how to do and such that quantifiable criteria can be included.
Need to identify: Specific to each Unit.

3. IBME competences

TOPIC 1: Previously acquired competences of students necessary for the Unit.
Aim: Determine previously acquired IBME competences (inquiry skills) of the students necessary for the Units if (is needed) identify and determine with competences have to be taught prior to the Unit.
Need to identify: Specific to each Unit.
TOPIC 2: Previously acquired competences of students necessary for the Unit.
Aim: Determine previously acquired IBME competences (inquiry skills) of the students necessary for the Units if (is needed) identify and determine with competences have to be taught prior to the Unit.
Need to identify: Specific to each Unit.
TOPIC 3: Competences (inquiry skills) that can be achieved thorough the Unit.
Aim: Determine IBME competences (inquiry skills) that will be stressed throughout the Unit.
Need to identify: Specific to each Unit.

4. Teaching/Learning activities and timetable

TOPIC 1: List of teaching and learning material and resources (print, non-print, digital, multimedia) and ways to share them with students.
Aim: Determine teaching and learning material and resources and ways to share them with the students.

Need to identify: How many resources lecturers are willing to use; available resources; presentation format; envisioned use of digital technology.

TOPIC 2: Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.
Aim: Lesson plan (order in which the Unit will be taught).
Need to identify: Activity sequence (lecturer and student tasks); essential inquiry questions; temporal scheme.

5. **Plan monitoring and assessment:** Designing plans for monitoring and assessment of the students and the Unit.

STUDENT ASSESSMENT: Determine how lecturers are going to monitor and assess student progress in both process ongoing basis and learning outcomes. There are many possibilities in planning assessment strategies, lecturers can consider different plans for diagnostic, formative and summative assessment and/or self-evaluation. Use of these strategies (and how lecturers do) depends on how long the IBME activity is and the kind of inquiry (structured[1], guided[2] or open[3]).

TOPIC 1: Plan for diagnosis:
Planned: At Stage 1.
Applied: During Stage 1 and 2.
Aim: Diagnostic assessment provides information (experiences and understanding of the scope) that students know and can do before new experiences are provided, and about their individual strengths and difficulties.
Application: Information used to take decisions and instructional plans (areas of more or less difficulty can be target for structured, guided or open inquiry activities).
Need to identify: Concrete questions that are testing understanding of students about specific topic or a knowledge quiz (or both).
Furthermore: Knowledge quiz can "wake up" students to be able to think about "what they already know".

TOPIC 2: Plan for formative assessment
Planned: At Stage 1.
Applied: During Stage 2.
Aim: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction.
Application: Helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity.

[1] **Structured Inquiry**: Lecturer provides a problem and the procedure for learners to address it.
[2] **Guided Inquiry**: Lecturer provides a problem, allowing learners to select a procedure to address it.
[3] **Open Inquiry**: Learners select the problem and the procedure to address it.

Need to identify: Monitoring achievement of learning scopes; how to measure evidences and how to give feedback on it. Consider use of rubrics.

TOPIC 3: Plan for summative assessment

Planned: At Stage 1.

Applied: During Stage 3.

Aim: Provide information (for students and teachers) about achievements on the inquiry activity and the learning outcomes.

Need to identify: quiz (multiple choice, fill in the blanks, free text…), resolution of activities, teacher-student interviews. Consider use of rubrics.

TOPIC 4: Plan for self-assessment

Planned: At Stage 1.

Applied: During Stage 2 and/or 3.

Aim: To help students to become more aware of IBME processes and their learning outcomes. Also, to encourage students to take more responsibility for their own learning.

Need to identify: Self-reflective activities; portfolio-based assessment strategies, self-assessment tests (checklists), peer-assessments (to assess students' participation skills in group activities; revising, and giving and receiving feedback); scoring rubrics.

UNIT ASSESSMENT: Determine how lecturer are going to monitor and assess the own Unit. This is carried out through plans for reflecting on the process, for evaluating and revising the assignment at the end of the process and for determining success of the process.

TOPIC 1: Plan for reflecting on the process

Aim: At each stage and step of the lesson plan in the Unit lecturer need to reflect on what students have learned, what they need to learn and how the process is going.

Application: For each purpose of the Unit identify strength, goals and next actions.

TOPIC 2: Plan for evaluating and revising

Planned: At Stage 1.

Applied: At Stage 3.

Aim: Evaluating and revising the task at the end of the process.

Need to identify: How was the task related to activity planning and implementation; content knowledge; procedural knowledge; teacher/student communications.

TOPIC 3: Plan for measure success of the process

Aim: Determine how lecturer will know if the process has been successful.

2.2.2. During the inquiry

During the inquiry lecturers observe and collect data for analysis and interpretation, about the students (*implementation of the* ***plan for formative assessment***) and the activity process (*implementation of the* ***plan for reflecting on the process***).

STUDENTS: Collecting data involves a variety of techniques, including both direct and indirect methods.

TOPIC 1: Questioning students (individually or in group) through:

- Discussions to check their understanding of the concept/topic/unit.
- Recording who is answering questions during classroom discussion.
- Asking students to comment or elaborate on one another's answers.

TOPIC 2: Interviewing students

- Circulating around the classroom during work and interviewing students about their work.
- Reviews to confirm their level of learning (knowledge and understanding).

TOPIC 3: Work products

- Activities carried out over a given time.
- Collecting and correcting work products and homework.
- Correcting tests (recording scores).

IBME ACTIVITY PROCESS: Following the plan for reflecting on the process:

- Taking notes on strategies that results more or less effective.
- For each purpose of the Unit identify strength, goals, if inquiry involves the expected on purpose, next actions.
- Reviewing student performance data collected and recorded and using them to make needed adjustments in the process.

2.2.3. After the inquiry

STUDENT ASSESSMENT: Student assessment involves:

1. **Comprehensive and criteria-based assessment.** Tools and criteria are specific for each Unit.

   TOOLS

   - Objective tests (true/false, multiple choice).
   - Free response tests.
   - Rubrics (useful for students to know in advance criteria of evaluation and performance levels, so they can plan for success).

   CRITERIA RECOMMENDATIONS

- Be based on demonstration of learner outcomes.
- Reflecting a variety of contexts.
- Including appropriate number of learner outcomes for each activity.
- Using criteria (based on evidences) to identify and evaluate performance tasks.
- Identify and clearly define the critical aspects of performance for demonstrating student learning.

2. **Revision of recorded student notes and formative assessment.**

IBME ACTIVITY ASSESSMENT AND REFLECTION: Learners must:

1. Summary, analyze and evaluate:
   - Adequacy of activity for inquiry.
   - Adequacy of scopes and grade of achievement.
   - Adequacy resources and activity plan.

2. Extract conclusions from the plan (and its results) for reflecting on the process and for evaluating and revising the assignment at the end of the process.

2.3. Assessment in IBME Environment: Detailed guidelines

In this section, we present first a short guide that compiles the different aspects that lecturer can consider when carrying out an IBME activity. Second, a detailed guideline is introduced, describing all points involved in the assessment, and including examples and recommendations. First one is recommended for lecturers experienced in *Inquiry* based education.

It must be noted again that in both cases, short and detailed guides, we provide an extended recompilation of possible aspects that can be considered for any kind of IBME activity. Depending on the kind of activity, duration, etc., lecturers can select those items appropriate for their activities (not all the listed points in the guide are mandatory for all kind of activity).

Assessment in IBME Environment: Short Guide

STAGE 1: BEGIN THE INQUIRY

Set goals, objectives and tasks. Identify inquiry skills (pre and post activity).

Set resources and formats. Design plans for the IBME activity (sequence, timetable, questions); for retrieval information during the inquiry and for monitoring and assessment, both the students and the own activity.

1.1. Pedagogic case (onwards Unit) opportunities for IBME

- Program of studies, course, aim of Unit, duration.
- Background knowledge relative to Unit and experience in Inquiry.
- Additional guidance for students.
- Unit opportunities to engage all students in the class.

1.2. Scopes

- Intended learning scopes (ILS) of the Unit.

1.3. IBME Competences

- Previously acquired competences necessary for the Unit.
- Competences that can be achieved thorough the Unit.

1.4. Teaching and learning material and resources

- Teaching/learning material and resources.
- Schedule time for students to browse through resources before the Unit.

1.5. Teaching/Learning activities and timetable

- Lesson plan.

1.6. Plan for monitoring and assessment

- Student assessment.
  - Plan for diagnosis.
  - Plan for formative assessment.
  - Plan for summative assessment.
  - Plan for student self-evaluation.
- Activity assessment.
  - Plan for reflecting on the process.
  - Plan for evaluating and revising.
  - Plan for measure success of the process.

STAGE 2: DURING THE INQUIRY

Observe, collect and analyse information for students and IBME task assessment.

2.1. Observations of the Students

- Information collected.
- Implementation and reviewing formative assessment plan.

2.2. Observations of the Activity Process

- Information collected.
- Implementation of ‘plan for reflecting on the process’.

STAGE 3: AT THE END OF THE INQUIRY

Final student assessment based on criteria; summative assessment and revision of formative assessment. Evaluating and revising of the own IBME task.

3.1. Student assessment

- Comprehensive and criteria-based assessment.
- Review record student notes and formative assessment.

3.2. IBME activity assessment and reflection

- Summary, analysis and evaluation.
- Conclusions.

Assessment in IBME Environment: Detailed Guideline

This Guide is designed to cover aspects involved in IBME Assessment for any kind of task. You must select from it those topics that fit and are useful to the type of activity that you are going to carried out.

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Guidelines

Program of studies	
Course name: Credits/hours:	
Pedagogic case	
Topic: Learning contents and Mathematical concepts: Aim of the Unit: Place of Unit in the course: Duration (hours/sessions):	
Others (For example: mandatory/voluntary …)	

Background knowledge relative to the Unit and background experience in Inquiry.

Guidelines

Learners profile (orientation, year, age): Size of the group:	
Homogeneity or heterogeneity of the group: Prior knowledge: Background experience in Inquiry:	
Others (For example: mathematicians/non-mathematicians …)	

Additional guidance for students.

Guidelines

- Additional guidance if needed (if any…):
- Special needs (if any…):
- Others: (Sample: additional guidance for …; before/during the Unit; resources used/given):

Unit opportunities to engage all students in the class.

Guidelines

- Opportunities to engage students (for highly motivated and those who require a lot of encouragement):
- Others:

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

Guidelines

- List of ILS:

Recommendations: Formulate ILS according the rules how to do.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

Guidelines

- List of IBME competences (inquiry skills):

Competences (inquiry skills) that can be achieved thorough the Unit.

Guidelines

- List of IBME competences (inquiry skills) that will be taught prior to the Unit:
- List of IBME competences (inquiry skills) that will be stressed throughout the Unit:

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

Guidelines

- List of material and resources and ways to share them (For example: printed, digital technology …):

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

Guidelines: activity sequence; essential inquiry questions; lecturer and student tasks; temporal scheme:

	Activity		Task		
	Description	**Question**	**Lecturer**	**Student**	**Time**
1 **2** **….**					

Recommendation: Let students know in advance when they will start an inquiry activity.

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

Guidelines

- Questions for testing understanding of students about specific topic.
- Knowledge quiz.

Recommendations: Concrete questions that are testing understanding of students about specific topic or a knowledge quiz (or both).

Example of topics and questions for testing conceptual understanding in assessment:

1. Reasoning

- Formulates or reformulates a problem, question or issue.
- Arrives at well-reasoned conclusions, solutions and implications.

- Integrates other disciplinary perspectives.

2. Strategies

- Gathers, assesses and analyses relevant information, data or evidence.

3. Representation

4. Data collection and measurements.

- Interpretation and analysis of data
- Computation
- Communication

5. Identification of issues for further studies

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

Guidelines: For each element in the list of learning outcomes:

- Status report on how well students can demonstrate specific learner outcome at that time.
- Rubrics.
- Evidences to be included and how to measure them.
- How to give feedback on formative assessment.
- ….

Recommendation: Make students aware of monitoring requirements.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

Guidelines

- Quiz (multiple choice, fill in the blanks, free text…)
- Resolution of activities.
- Portfolio-based assessment strategies.
- Teacher-student interviews.
- Rubrics.
- Any summative task that allows students to demonstrate their conceptual understanding of the learning outcomes.
- ….

Recommendation: Make students aware of assessment requirements.

Plan for student self-evaluation.

Guidelines

- Self-reflective activities.
- Portfolio-based assessment strategies.
- Self-assessment test (e.g. checklist; score rubrics).

- Peer-assessments (to assess students' participation skills in group activities; revising, and giving and receiving feedback).
- ….

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

Guidelines: For each purpose identify:

- Strength, goals and next actions.
- If inquiry involves the expected on purposes.

Plan for evaluating and revising the task at the end of the process.

Guidelines:

Activity planning and implementation (content and process): from lecturer and students quizzes.

Indicator	**Achievement criteria**
Unit plan Implementation practicality Performance practicality …..	

Content knowledge: test tools (students assessment) to measure knowledge competences):

Indicator	**Achievement criteria**
Fundamental concepts (mathematical ideas at the heart of each activity) Coherent conceptual understanding. Connections with other content and disciplines and/or real world phenomena. …..	

Procedural knowledge (non-test tools to measure attitude and skill competences):

Indicator	**Achievement criteria**
Mathematics learning interest Mathematics attitude	

Learning motivation (students engaged in thought provoking activities.) Mathematic process skills Mental processes to express ideas; Conjectures (estimations and tools to test and then validate or reject) …..	

Plan for measure success of the process: Determine how you will know if the process has been successful.

STAGE 2: DURING THE INQUIRY
– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Guidelines

Observation	**Text notes, checklist, anecdotal report, …**
Classroom discussion	Understanding, answers; comments, responses, learning conversations, use of strategies, questioning, behaviour, engagement. …
Student interviews	Knowledge and understanding.
Work product	Activities completion and time, use of materials and tools, homework, score tests, …
Other specific observations recorded on an ongoing basis which can provide useful data for analysis and interpretation).	

Implementation and reviewing formative assessment plan.

Guidelines

- Follows plan for formative assessment in the above observations.

Recommendations (teacher self-questioning):

- Did the students benefit from …?
- Did my plan provide the intended effect and results? Why do I think that?
- What changes should I make for …?
- What other topics can I revise to include more formative elements?

2.2. Observations of the Activity Process

Information collected.

Guidelines

Observation	**Text notes, checklist, anecdotal report, …**
List of purposes of the Unit:	Strength, goals, does inquiry involves the expected? Effectiveness of strategies, next actions …
From student performance data collected:	Needed adjustment

Implementation of 'plan for reflecting on the process'.

Guidelines

- Follows plan for reflecting on the process.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.

Guidelines

- Be based on demonstration of learner outcomes.
- Reflecting a variety of contexts.
- Including appropriate number of learner outcomes for each activity.
- Using criteria (based on evidences) to identify and evaluate performance tasks.
- Identify and clearly define the critical aspects of performance for demonstrating student learning.

Review record student notes and formative assessment.

Guidelines (be based on demonstration of learner outcomes).

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Guidelines

Unit opportunities for IBME	Adequacy
Learning contents Topic Aim Place and duration Learner profile Size group Prior knowledge Background experience in inquiry Additional guidance Students engagement	

Scopes (list)	Adequacy

IBME Competences (list)	Adequacy

Material and resources (list)	Adequacy

Lesson plan

Activity (list)	Adequacy	Duration	Adequacy

Diagnosis plan	Adequacy

Formative assessment (plan and implementation)	Adequacy

Summative assessment (plan and implementation)	Adequacy

Self-evaluation (plan and implementation)	Adequacy

Reflecting on the process (plan and implementation)	Adequacy

Evaluating and revising (plan and implementation)	Adequacy

Conclusions.

Guidelines

- Lecturer final conclusions.

3. Case studies: Analysing and reporting results

In this work we have considered five cases of studies. For simplicity, we denote onwards the cases from A to E.

CASE	TITLE
A	'Computer Sciences: Rewriting logic'
B	'An escape game with differential equations'
C	'Numerical series'
D	'Events and their probability'
E	'Bad questionary'

A description for each case and detailed assessment process is given in the appendix. In this section we present only a brief description of the cases and we focus here in the analysis of their assessment and report our main conclusions. We present and discuss this section following the stages in the inquiry process as introduced in previous sections.

Stage 1: Begin the inquiry

Four cases (B to E) belong to different levels of bachelor degree programs whereas case A correspond to a Master's degree. Likewise, cases A, B and C correspond to Mathematics and Science studies while cases D and E are for Economics and Administration (this is, not mathematicians students). Each case present a pedagogic Unit corresponding with a topic inside a general Course. Each Unit developed has different time length: from 20 minutes (in one session, e.g. case E) up to 12-15 hours (in multiple sessions, e.g. case A).

As usually happens at University courses, the groups of students are heterogeneous in all cases, with different levels of knowledges (more pronounced at Master level) and none or minimal experience in Inquiry activities. Also, the size of the groups for which the Unit are developed ranges from a few students (no more than ten, e.g. case C) up to hundreds of them (e.g. case D).

In all the cases, lecturers had previously determined and prepared any needed additional guidance (for before the activity or for the time of it) and a full lesson plan is prepared (activity sequence and time table). It must be noted that before the activity lecturers had clearly identify in each case (to be sure that the objectives proposed with the Unit can be satisfactorily achieved):

- The Unit opportunities to engage all students.
- A list of intended learning scopes.

- Competences (previously acquired by the students) necessary to deal with the Unit and those competences that could be achieved through the Unit.
- Available teaching and learning material and resources.

Finally, developed plans for monitoring and assessment (student and activity) varies a lot from one case to another. It is clear that for shorter activities not all plans suggested in the guidelines are necessary or useful, some of these plans (e.g. diagnosis, formative, for reflecting on the process) can be, for example, limited to activities prolonged in time (e.g. during a semester). In our cases, we found:

- Plan for diagnostic:
  - Case E, as the Unit takes place at the beginning of the course it is not necessary a plan for diagnostic. Indeed, the Unit is developed to be itself a diagnostic of the state of the students.
  - Case D, the additional guidance supplied to students (see Section 1.1 of the Guide) before the activity is prepared so that the students are well prepared for the activity and no diagnostic plan in needed again.
  - Cases B and C are essentially based on the fact that the sequence of activities (see Section 1.5. of the guide) is developed so that at the end of each activity the lecturer can detect students' problems and give them feedback. Also, the teacher interviews students during the process.
- Plan for formative assessment: In all cases, lecturers establish how they are going to retrieve information about students' progress (on reasoning, strategies and son on) either for a list of learning outcomes (e.g. case A) or for the entire activity.
- Plan for summative assessment: In general, summative assessments are based in the final resolution of tasks or quiz (inside the Unit) at the end activity but also (as case C) by applying the acquired competences in a new practical lesson.
- Plan for student self-evaluation: All cases considered present particular and different plans, so it can be seen that everything depends on the Unit designed.

With respect plans for the activity assessment it can be seen a very detailed plans in cases A, D and E, where indicators and achievement criteria are listed for content and procedural knowledge involves in the tasks. More general plans can be seen in case B and none specified in case C.

Stage 2: During the inquiry

All cases follow most of the recommendations given in the Guide. For a detailed description see cases in the appendix.

Stage 3: After the inquiry

The final students assessment in the cases presented is based in formative assessment (this is mainly due to the short duration of the considered activities).

Finally it should be noted that the activity assessment recommendations seem to be useful for any kind of activity as all cases follow them in a similar way.

4. Conclusion

In this document we have presented the guidelines for developing inquiry-based activities. These activities must be designed taking into account both the students' view (that is, what are they supposed to learn and how) and the lecturers' view (that is, how will the lessons be analyzed to study their effectiveness). We have proposed to distinguish three stages to help the designer of the tasks: before the inquiry, during the inquiry, and after the inquiry, highlighting the main goals of each stage.

Then, we have presented some case studies that confirm the usefulness of the guidelines. These case studies include a wide range of subjects, degrees, and activities, exemplifying how the guidelines are instantiated in different cases. Designers can use these case studies as starting point for developing their own activities.

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Appendix

In this appendix we present a collection of examples implementing the guidelines in the previous section. These examples include:

- Inquiry in Computer Science, developed at the Universidad Complutense de Madrid by Adrián Riesco. This case study presents a unit for teaching Logic to Master's students.

- Inquiry in Calculus, developed at the Universidad Complutense de Madrid by David Gómez, Teresa Luque and Inés Gómez Chacón. This case study presents how to introduce differential equations by means of an escape game.

- Inquiry in Mathematical Analysis, developed at the Borys Grinchenko Kyiv University by Mariia Astafieva, Oksana Hlushak and Oksana Lytvyn. This case study presents an activity used to teach convergence of series.

- Inquiry in Statistics, developed at the Masaryk University by Maria Králová. This case study presents an exercise to deduce the meaning of probability by means generalization.

- Inquiry in Statistics, developed at the Masaryk University by Maria Králová. This case study describes an activity for learning how to avoid bad questions in questionnaire design.

CASE A: 'Computer Sciences: Rewriting logic'

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Program of studies	Master's degree in Computer Science
Course name:	Software auditory and quality assurance
Credits/hours:	6 credits / 60 hours
Pedagogic case	
Topic:	Formal specification and model checking
Learning contents and Mathematical concepts:	Specification of system using equational and rewriting logic, LTL, and model checking.
Aim of the Unit:	Making sure the students recognize the elements in equational logic to fully define a simple system.
Place of Unit in the course:	3rd month (out of 4)
Duration (hours/sessions):	12 hours / 6 sessions
Others (For example: mandatory/voluntary …):	Mandatory.

Background knowledge relative to the Unit and background experience in Inquiry.

Learners profile (orientation, year, age):	Around 22-23, bachelor degree in computer science.
Size of the group:	20
Homogeneity or heterogeneity of the group:	Heterogeneous, because master students might come from other Spanish universities and even from abroad.
Prior knowledge:	First-order logic.
Background experience in Inquiry:	Not required.

Additional guidance for students.

Additional guidance:	Through the activity
Special needs:	NO
Others:	A guide with all information is handed to students, but they are not required to read it beforehand.

Unit opportunities to engage all students in the class.

Use of games to engage students. They work in teams of different sizes, depending of the stage.

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

List of ILS:

- Improve knowledge on transitions systems and verification.
- Improve skills for model checking.
- Learn to use Maude.
- Expand knowledge on graph theory and declarative programming.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

Undetermined, master students have varied background.

Competences (inquiry skills) that can be achieved thorough the Unit.

- **List of IBME competences (inquiry skills) that will be taught prior to the Unit:**
  Specification and verification of systems.
- **List of IBME competences (inquiry skills) that will be stressed throughout the Unit:**
  Formal definition of properties using logic.

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

List of material and resources (and ways to share them):

- Printed: guide and examples via Virtual Campus.
- Digital technology: programming language Maude.
- Live discussion with the teacher and in teams.

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

1 hour before each session.

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

	Activity		Task		
	Description	Question	Lecturer	Student	Time
1	Introduction to specification languages	How to specify simple Mathematical elements in equational logic?	Simple examples	Work in teams to finish what the teacher starts	2 hours
2	Lab: specify binary trees	How to specify a binary tree with the previous ideas?	List of intermediate questions	The whole class works as a team to solve it	2 hours
3	Transition systems	How to specify games using transition systems	Explains the basic and presents games	The whole class as a team solves them	2 hours
4	Lab: transition systems	How to specify a particular example with transition systems?	List of intermediate questions	Students works in pairs to solve it	2 hours
5	Introduction to LTL	How LTL explains daily live events?	Basic problems that can be expressed in LTL	The whole class as a team solves them	2 hours
6	Lab: advanced transition systems	How to solve this game with a transition system?	Presents the problem	Students works in pairs to solve it	2 hours

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

The assignment in Session 6 above is marked. The mark takes into account whether the students understand the problem, find an appropriate way to solve it, and do it in Maude.

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

- Assignment in Session 4 above is handed and feedback is given to students, although no marks are given.
- Discussions on Sessions 1, 3, and 5 above are annotated and feedback is given immediately.
- Rubrics: Solutions are judged based on how simple are and how well they fit the problem.
- Maude code and comments explaining why the commands in the program have been chosen
- Face to face and via Virtual Campus.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

- Resolution of activities.
- Teacher-student interviews.
- These activities are marked according to rubrics discussed with the students beforehand.

Plan for student self-evaluation.

- Maude code is executable, so the students obtain feedback by executing it.
- Peer evaluation, because activities are done in pairs.

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

- Analyzing most common errors by students.

- Analyzing whether each activity takes as much time as expected. Subdivide them if too much time is required and complete them if too much time was allocated.

Plan for evaluating and revising the task at the end of the process.

Activity planning and implementation (content and process): from lecturer and students quizzes.

Indicator	Achievement criteria
Unit plan	All skills are obtained
Implementation practicality	Students that follow the lectures are able to finish the assignments
Performance practicality	Students finish it in the lab

Content knowledge: test tools (students assessment) to measure knowledge competences):

Indicator	Achievement criteria
Fundamental concepts (mathematical ideas at the heart of each activity)	Explanations correct in assignments
Coherent conceptual understanding.	All activities of each assignment are finished and correct
Connections with other content and disciplines and/or real world phenomena.	Assignments based on real world activities are completed

Procedural knowledge (non-test tools to measure attitude and skill competences):

Indicator	Achievement criteria
Mathematics learning interest	Discussion with students
Mathematics attitude	Discussion with students
Learning motivation (students engaged in thought provoking activities.)	Open questions, discussing during lectures
Mathematic process skills	Assignments finished
Mental processes to express ideas;	Presentation by students
Conjectures (estimations and tools to test and then validate or reject)	Interviews while assignments are being completed

Plan for measure success of the process: Determine how you will know if the process has been successful.

Besides the quiz given by the university, I give them open questions to reflect on the process. I also check the marks of the students that attended the lectures.

STAGE 2: DURING THE INQUIRY
– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Observation	Text notes, checklist, anecdotal report, …
Classroom discussion	Understanding Engagement to solve the questions asked during the classroom. Chained questioning (students ask other students).
Student interviews	Knowledge Understanding
Work product	Activities completion and time. Use of materials and tools.

Implementation and reviewing formative assessment plan.

2.2. Observations of the Activity Process

Information collected.

Observation	Text notes, checklist, anecdotal report, …
List of purposes of the Unit:	Strength Goals Does inquiry involves the expected? Effectiveness of strategies. Next actions
From student performance data collected:	Needed adjustment

Implementation of 'plan for reflecting on the process'.

If the students take less/more time than expected or they do not reach the expected conclusions, more inquiry or different activities is required in the previous stages. I would try both and see how the results change.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.

Review record student notes and formative assessment.

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Unit opportunities for IBME	Adequacy
Learning contents	Formal verification of software
Topic	Quality assurance
Aim	Learning to verify software
Place and duration	In class, 12 hours
Learner profile	Master student in Computer Science
Size group	20
Prior knowledge	Degree in Computer Science
Background experience in inquiry	Undetermined
Additional guidance	Through the lectures
Students engagement	Discussion

Scopes (list)	Adequacy
Specification	Mathematical concepts learned
Verification	Using model checking

IBME Competences (list)	Adequacy
Specification and verification of systems	Defining systems in Maude
Formal definition of properties	Using Maude model checker

Material and resources (list)	Adequacy
Maude	Students can program simple specifications

Conclusions.

CASE B: 'An escape game with differential equations'

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Program of studies	Bachelor's degree in Mathematics, Mathematical Engineering and Mathematics & Statistics (3 different degrees which are joined for the first two years).
Course name:	Elements of Ordinary Differential Equations (ODEs).
Credits/hours:	6 credits / 60 hours
Pedagogic case	
Topic:	Linear ODEs, solvable models and qualitative behavior of simple systems.
Aim of the Unit:	Meaningful examples on the topic.
Place of Unit in the course:	The task is proposed half-way through the semester, so students have been given some tools of analysis of ODEs.
Duration (hours/sessions):	1 session (3 hours).
Others (For example: mandatory/voluntary …):	The subject is compulsory for the degree.

Background knowledge relative to the Unit and background experience in Inquiry.

Learners profile (orientation, year, age):	Mathematicians; 2nd year of studies of the degrees of Mathematics, Mathematics and Statistics (M&S) and Mathematical Engineering (ME).
Size of the group:	20
Homogeneity or heterogeneity of the group:	Heterogeneous (different level of knowledge).
Prior knowledge:	The students are assumed to have master skill of calculus of one real variable analysis.
Background experience in Inquiry:	No prior inquiry activities have been conducted on the students.
Student's interest:	Variable. Some students seem more interested in the physical examples and modeling in general (ME and M&S), whereas some are more interested in the analytical techniques.

Additional guidance for students.

Additional guidance:	Given throughout the activity. There is only one (reasonable) way to solve the problem. This method

	requires several ingenious ideas (choice of variables…) which is unlikely the students (except for the very talented) will devise on their own. We wrote down the basic steps in some detail, in independent pieces of paper, to be provided upon student's request (clues).
Special needs:	NO
Others: A guide with all information is handed to students, but they are not required to read it beforehand.	

Unit opportunities to engage all students in the class.

The students are proposed a modeling problem, which can be translated into an Ordinary Differential Equation (ODE), which they are meant to solve with the techniques from the course and previous years.

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

List of ILS: the aim of this task is to understand the trajectory of a dog pursuing a hare and understand whereas (or not) the dog manage to catch the dog. This aim joins together the following aspects:

- Modelling the problem with differential equations: identify the problem variables and construct the differential equation to be solved.
- Solve the differential equation using standard methods.
- Interpret the mathematical solution: answer the question made in the original problem.

Observations

- **Knowledge**: The task is not intended to introduce new concepts or techniques.
- **Improve skills**: The proposed task is an exercise to help the students apply several techniques given in the course: implicit function theorem, change of variable, change of unknown function... The intuition for the choice of the correct techniques is to come from the modeled problem.
- **Learn to use / expand knowledge**: As indicated above.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

Since these students they are students of a Mathematics degree some (implicit) exposure to inquiry comes, and the "way of though" is not altogether foreign.

Competences (inquiry skills) that can be achieved thorough the Unit.

- **List of IBME competences (inquiry skills) that will be taught prior to the Unit:** None. This is the first IBL activity for the students.
- **List of IBME competences (inquiry skills) that will be stressed throughout the Unit:** The students are invited to think carefully, make 'wild guesses' and go back to the modeling for inspiration. Some of the techniques require a 'deep' understanding and handling of concepts of the 1st year. Students are encouraged to go back and re-think their understanding of theorems (e.g. the implicit function theorem).

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

List of material and resources (and ways to share them):

- The students work in groups of 4 and 5 students. They are encouraged to exchange ideas. They provide a solution as a group.
- The students may use only pen and paper to solve the problem.
- The proposed problem is handed on pieces of paper to each group. The statement is short and occupies roughly one fourth height of an A4 piece of paper (full width).
- Upon student's request 'clues' are provided, indicating the next suggest step.
- The supervising lectures (2 for 5 groups) offer their help for revising need theory, understanding the model, or performing computations.
- The students need no preparation for facing the task. The activity last 3h. We reserve a final hour for activity evaluation and comments.

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

None

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

	Activity	
	Description	**Question**
1	*Activity* 1	1 question
2	*Activity* 2	10 questions (guided inquiry)
3	*Activity* 3	Open inquiry

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

The way the activities were designed (through stages with gradual difficulty) together with the implemented clues gave information to adapt the game during the execution. In fact, some clues were improvised.

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

Students' interactions during the activity are recorded in video, and their scrap paper retrieved. Supervisors interact with the students for questions and monitoring during the activity. Final questionnaire and group interview.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

- Resolution of activities.
- Teacher-student interviews (see formative assessment).

Plan for student self-evaluation.

- **Self-assessment:** The students are given a questionnaire for evaluation of the activity and self-reflection.
- **Peer-assessment**: After the questionnaire, there is a group discussion (led by an independent researcher) which is video recorded. Also, the lecturers proposing the activity record their impression separately.

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

Plan for evaluating and revising the task at the end of the process.

- Activity planning and implementation (content and process): from lecturer and students quizzes: From the complete process and it is collected in stage 3
- **Content knowledge**: test tools (student's assessment) to measure knowledge competences): From the complete process, the questionary for self-reflection and the resolution of the problem. All of these are collected in stage 3
- **Procedural knowledge** (non-test tools to measure attitude and skill competences): From the complete process and it is collected in stage 3

Plan for measure success of the process: Determine how you will know if the process has been successful.

It is based on the whole review.

STAGE 2: DURING THE INQUIRY
– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Observation	Text notes, checklist, anecdotal report, …
Classroom discussion	Understanding Answer, comments,

	Learning conversation Use of strategies Questioning Behavior, engagement
Student interviews	Knowledge Understanding
Work product	Activities completion and time. Use of materials and tools.

Implementation and reviewing formative assessment plan.

Follows plan for formative assessment based in the above observations.

Teacher self-questioning:

- Did the students benefit from the activity?
- Where the clues useful to break the obstructions?
- Did my plan provide the intended effect and results? Why do I think that?
- What changes should I make for providing a better understanding of the concepts involved?
- What other topics can I revise to include more formative elements?
- Was the timing suitable for the tasks or was too much ambitious?

2.2. Observations of the Activity Process

Information collected.

Observation	Text notes, checklist, anecdotal report, …
List of purposes of the Unit:	Strength Goals Does inquiry involves the expected? Effectiveness of strategies. Next actions Individual thinking versus group thinking The efficacy/inefficacy of the clues to progress in the tasks.
From student performance data collected:	Needed adjustment

Implementation of 'plan for reflecting on the process'.

Follows plan for reflecting on the process.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.

Review record student notes and formative assessment.

- **Mathematical knowledge:** Evidences based on final resolution of the problem.
- **Procedural knowledge:** Evidences based on the notes and formative assessment.

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Adequacy levels: 0 = low; 1 = medium; 2 = High
NA = Not Applicable

Unit opportunities for IBME	Adequacy
Learning contents	1
Topic	2
Aim	2
Place	2
Duration	0
Learner profile	1
Size group	2
Prior knowledge	2
Background experience in inquiry	0
Additional guidance	NA
Students engagement	2

Scopes (list)	Adequacy
Modelling the problem with differential equations	2
Solve the differential equation	2
Interpret the mathematical solution	2

IBME Competences (list)	Adequacy
Previous	1
Taught prior to the Unit	2
Stressed throughout the Unit	2

Material and resources (list)	Adequacy
Material and resources	2

Lesson plan			
Activity (list)	**Adequacy**	**Duration**	**Adequacy**
Activity 1	2		2
Activity 2	1		0
Activity 3	NA		NA

Diagnosis plan	Adequacy
Diagnosis plan	2

Formative assessment (plan and implementation)	Adequacy
Plan	2
Implementation	1

Summative assessment (plan and implementation)	Adequacy
Self-assessment	2
Peer-assessments	2

Self-evaluation (plan and implementation)	Adequacy
Plan	2
Implementation	2

Conclusions.

The students indicated that they found the activity quite enriching. Participating in an activity as a group, and one that was also a game, energized them and this challenge led them to take advantage of the lessons previously learned (even in earlier years) to help their team. We see this both in the videos and also in the high rating they gave to the proposal. They all indicated that they would like to participate in additional similar activities, as they found less interesting the more routine ones they were more used to. Although they did not mention that they learned new concepts, they certainly benefitted from putting them into practice in an active and real way by modeling.

Nevertheless, for us the activity turned out differently from what we had expected:

- The clues did not reach the obstacles of the groups, and there would have had to be a tutor for each group to make a truly effective activity, in which the teacher overcame the problems and could guide them in an effective manner.
- Furthermore, the assumption was that the students had previously reviewed certain concepts, and for the great majority this was not the case; a better preparation for the activity would have led to a better outcome.

CASE C: 'Numerical series'

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Program of studies	Bachelors of Mathematics, 1st year
Course name:	Mathematical Analysis
Credits/hours:	11 Credits, 330 hours
Pedagogic case: «Using IBL technology to form conceptual knowledge of mathematics on the example of studying numerical series»	
Topic:	Absolute and conditional convergence of numerical series
Learning contents and Mathematical concepts	Absolutely and conditionally convergent series; application to the study of convergence of series.
Aim of the Unit:	- Introduce students to the concept of absolute (conditional) convergence of a series and its applications to the analysis of convergence of non-positive term series. - Contribute to the formation of conceptual understanding of mathematics, development of exploratory and procedural skills.
Place of Unit in the course:	Content module "Series"
Duration (hours/sessions):	1 sessions (2 hours)
Others (For example: mandatory/voluntary …):	The topic is mandatory.

Background knowledge relative to the Unit and background experience in Inquiry.

Learners profile (orientation, year, age):	Mathematics, 1st year.
Size of the group:	8 students
Homogeneity or heterogeneity of the group:	Different level of knowledge
Prior knowledge:	- numerical series, convergence and divergence of numerical series, the sum of convergent series; - properties of convergent series; - necessary condition for convergence of a positive term series; - Cauchy convergence criterion; - tests for convergence of positive term series; - Leibniz test for convergence of alternating series; - understanding what is a sufficient condition (sign); necessary condition;

	- understanding in which cases the use of the necessary condition of convergence of a series can be effective and the ability to use it; skills of research of convergence of positive and alternating series by means of sufficient signs
Background experience in Inquiry:	IBL experience is minimal (during the first semester)
Others	Mathematicians

Additional guidance for students.

Additional guidance:	The teacher directs the activities of students directly in the lecture.
Special needs:	NO

Unit opportunities to engage all students in the class.

Teacher creates the situation where the student must recognize (see, feel) the need for a new knowledge. Namely, it offers students to investigate the convergence of a series (which contains both positive and negative terms) and students find themselves in a situation where their existing knowledge is not enough.

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

List of ILS:

- **Knowledge**: sufficient condition for the convergence of a series (absolute convergence); the concepts of absolutely and conditionally convergent series.
- **Specific kills**: testing series for absolute (conditional) convergence.
- **General exploratory and procedural skills**: analogic reasoning, empirical reasoning, assumption making, understand of mathematical proof; ability to argue.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

- ability to analyse,
- the ability to formulate questions that help in finding results
- ability to make hypotheses,
- understand the essence of mathematical proof

Competences (inquiry skills) that can be achieved thorough the Unit.

List of IBME competences (inquiry skills) that will be stressed throughout the Unit:

1) ability to make analogies, empirical reasoning, make assumptions, prove; the ability to argue.
2) As a result of joint discussion of ways to solve the problem, students formulate a hypothesis, find ways to prove it, choose the optimal one (checking the Cauchy criterion of convergence of the series).

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

List of material and resources (and ways to share them):

- The lecture is held online using the resource Zoom.
- The teacher demonstrates a screen with a presentation and display of a document camera, through which students see a sheet of paper where the teacher makes notes (lecture notes).
- To solve the problem, students in turn put forward ideas, formulate questions and answer questions from the teacher.

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

Not planned

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

	Activity		Task	
	Description	**Question**	**Lecturer**	**Student**
1	**Task**: test the following series for convergence: $\sum_{n=1}^{\infty} \frac{\sin n}{n^2}$.	Structured inquiry	Acts as a facilitator during the discussion of the problem and ways to solve it: helps, guides, discusses, opposes, if necessary, gives counterexamples, provokes, asks questions that lead to the correct conclusion that: - convergence tests for positive term series cannot be applied; - it is also not possible to reduce the problem to the study of a Leibniz-type series.	- Analyze, reflect, discuss, ask questions that help to advance the study, express ideas and oppose; - Formulate hypotheses; - As a result of the discussion, come to the decision about how to proceed - to check Cauchy's convergence criterion for a series or to investigate the series convergence by using the definition.
2	**A.** Proof of the formulated hypothesis using the Cauchy criterion: $\forall \varepsilon > 0, \forall p \epsilon N$ such that $\lvert a_{n+1} + \cdots + a_{n+p} \rvert \leq \lvert a_{n+1} \rvert + \cdots + \lvert a_{n+p} \rvert < \varepsilon$. **B.** Formulation of the theorem. **C.** Conclusion regarding the convergence of the series $\sum_{n=1}^{\infty} \frac{\sin n}{n^2}$. **D.** Find out whether this condition for convergence is also necessary.	Structured inquiry	- Writes down the proof of the theorem (if possible, involves students in commenting); - Acts as a facilitator in the discussion of a new problem: what can be said about a given series, if a new series formed by using the absolute values of its terms is divergent? - Formulates the definitions of absolutely and conditionally convergent series;	- Write in notebooks (synchronously with the teacher) the formulation and the proof of the theorem about absolute convergence of a series, - on the basis of the discussion, come to the conclusion that the convergence condition proved is not necessary. Give an appropriate counter-example to illustrate this fact (independently or with the help of the teacher).

	E. Definition of absolutely (conditionally) convergent series. **F.** Formulation of the theorem and the topic of the lecture on the board.			
3	Examples of the series to be tested for absolute (conditional) convergence $A)\ \sum_{n=1}^{\infty}\frac{(-1)^n n^3}{3^n}$; $B)\ \sum_{n=1}^{\infty}\frac{(-1)^{n+1}}{\ln(n+1)}$; $C)\ \sum_{n=1}^{\infty}\frac{(-1)^n\left(\frac{n+1}{n}\right)^{n^2}}{4^n}$; $D)\ \sum_{n=1}^{\infty}\frac{(-1)^n n^n}{n!}$	Structured inquiry	Provides exercises for training; exercises are selected so as to bring students to the question: is it possible in some cases (and in which exactly) from the divergence of a series of members modules to draw a conclusion about the divergence of the studied series.	- Comment on the solution, writing notes.
4	We have already established that the convergence of the series $\sum_{n=1}^{\infty}\lvert a_n\rvert$ (2) implies the convergence of a series $\sum_{n=1}^{\infty}a_n$. (1) If the series (2) is divergent, then the series (1) can be either convergent or divergent, which is confirmed by the above examples.	Structured inquiry	Encourages the hypothetical conclusion. But in the end she formulates it herself and invites students to prove it.	- suggest its proof; - reflect about practical significance of the acquired knowledge; - give relevan examples.

		However, we note that, in the case of series D, the series of modules of its members was divergent and the investigated series is also divergent. Why can we draw such a conclusion? Isn't this related to the way the series (2) differs?			

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

The teacher provoked students while solving problems, gave counterexamples, pushed by means of questions to the right conclusions.

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

Class discussions were recorded on video. Observers make certain notes.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

Since the form of the lecture does not involve a summative assessment of students' knowledge, the summative assessment of the study of the topic can be carried out after the practical skills formation of applying the acquired knowledge in a practical lesson.

Plan for student self-evaluation.

- **Self-reflective activities** - at the end of the lesson students evaluate their own progress, comparing their understanding with previous knowledge, formulate new questions that deepen the concept or topic.
- **Expert assessment** - after the lesson, experts discuss the activities of students.

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

Plan for evaluating and revising the task at the end of the process.

Plan for measure success of the process: Determine how you will know if the process has been successful.

STAGE 2: DURING THE INQUIRY

– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Observation	Text notes, checklist, anecdotal report, …
Classroom discussion	Understanding Answer, comments, Learning conversation Use of strategies Questioning Behavior, engagement
Student interviews	Knowledge Understanding
Work product	Activities completion and time. Use of materials and tools.

Implementation and reviewing formative assessment plan.

2.2. Observations of the Activity Process

Information collected.

Observation	Text notes, checklist, anecdotal report, …
List of purposes of the Unit:	Strength Goals Does inquiry involves the expected? Effectiveness of strategies. Next actions
From student performance data collected:	Needed adjustment

Implementation of 'plan for reflecting on the process'.

Follows plan for reflecting on the process.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.

Review record student notes and formative assessment.

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Adequacy levels: 0 = low; 1 = medium; 2 = High
NA = Not Applicable

Unit opportunities for IBME	Adequacy
Learning contents	2
Topic	2
Aim	2
Place	1
Duration	1
Learner profile	1
Size group	1
Prior knowledge	1
Background experience in inquiry	1
Additional guidance	NA
Students engagement	2

Scopes (list)	Adequacy
Knowledge: sufficient condition for the convergence of a series (absolute convergence); the concepts of absolutely and conditionally convergent series.	2
Specific kills: testing series for absolute (conditional) convergence.	2
General exploratory and procedural skills: analogic reasoning, empirical reasoning, assumption making, understand of mathematical proof; ability to argue.	1

IBME Competences (list)	Adequacy
Previous	1
Stressed throughout the Unit	2

Material and resources (list)	Adequacy
Training material	2

Lesson plan	
Activity (list)	**Adequacy**
Activity 1	2
Activity 2	2
Activity 3	2
Activity 4	1

Diagnosis plan	Adequacy
Diagnosis plan	1

Formative assessment (plan and implementation)	Adequacy
Plan	2
Implementation	2

Summative assessment (plan and implementation)	Adequacy
Self-assessment	NA
Peer-assessments	NA

Self-evaluation (plan and implementation)	Adequacy
Plan	2
Implementation	2

Conclusions.

In the comments after the lecture, the students noted that with each subsequent lesson, they become more confident that they can prove, look for solutions to the problems set by the teacher and find their solutions. Some students were interested in the permutable property of a conditionally convergent series, and wanted to know how to prove it.

We believe that these responses of students indicate their involvement, activity, and ability to analyse and desire to prove. As a result, we can say that the goal of the lesson was achieved, all tasks were implemented.

CASE D: 'Events and their probability'

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Program of studies	Bachelor's degree, all fields of study of the Faculty of Economics and Administration.
Course name:	ESF:BPM_STA1 Statistics 1
Credits/hours:	5 credits
Pedagogic case:	
Topic:	Events and their probability.
Aim of the Unit:	Learning of the meaning of probability by generalization of the exercise.
Place of Unit in the course:	The task is proposed at 4th lection, at the beginning of using terms of an event and probability.
Duration (hours/sessions):	30-40 minutes
Others (For example: mandatory/voluntary …):	The subject is mandatory for the degree.

Background knowledge relative to the Unit and background experience in Inquiry.

Learners profile (orientation, year, age):	Non-mathematicians, 1st semester of the 2nd year study.
Size of the group:	Max 350 students.
Homogeneity or heterogeneity of the group:	Heterogeneous (different level of knowledge).
Prior knowledge:	All students had mandatory mathematics at the 1st year of study.
Background experience in Inquiry:	Basically, students did not have any experience in inquiry, there was some "preparation" for it in form of lecturer's dialog with students and few questions to discus in groups during previous lectures.

Additional guidance for students.

Additional guidance:	Students should be able to derive probability characteristics after solving an experimental exercise and generalized its results.
Special needs:	NO

Unit opportunities to engage all students in the class.

The unit suppose to be good for engaging all students, because it is unusual for them to be so much involved in lecture process so it supposed to be something new and

interesting to try. Moreover, the unit is for a new topic, so students wouldn't be afraid to try even if they miss some previous topic.

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

List of ILS:

Use the definition of classical probability to solve the exercise.
Try to replace "?" sign in the second exercise using results of the previous one.
Generalization of all results for obtaining the probability characteristics.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

None, because students don't suppose to have any experience in inquiry.

Competences (inquiry skills) that can be achieved thorough the Unit.

List of IBME competences (inquiry skills) that will be taught prior the Unit: None, for almost all students this could be a first inquiry task.

List of IBME competences (inquiry skills) that will be stressed throughout the Unit: Students are supposed to derive theoretical part of the lecture by themselves using the exercise. So they have opportunity to "discover" something, what they regularly use as definition or theorem from the lecture, by themselves and that is why understand it better.

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

List of material and resources (and ways to share them):

- Students could use their notation and/or printed lecture materials.
- Students obtain printed papers with all combinations of a dice roll, which they may need for a task to make it easier. Also, they can use it for solving, make notes on it.

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

Students have opportunity to read materials of the lecture before it, but it is very small probability that at least few of them did it (they should not prepare for a lecture).

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

	Activity		
	Description	Question	Time
1	Activity 1	9 questions	10 minutes for solving and 5 minutes for a discussion
2	Activity 2	5 questions	10 minutes for solving and 5 minutes for generalization of the results

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

Before the start of an activity (at the previous part of the lecture) students obtained theoretical information about an event and probability.

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

During the activity the lecturer walked through the class, communicated with groups. From time to time asked students to raise the hand if they have solved a particular question. Also teacher can control situation by the sound – students almost finished the exercise when all talks stops.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

- The teacher can see students' understanding of the topic by their hands raising.
- Collective control/discussion of the right answers for the exercise.
- Collective generalization of the results from exercises (to obtain characteristics of probability), when students could demonstrate their conceptual understanding of the learning outcomes.

Plan for student self-evaluation.

During collective control of the right answers students can evaluate their level of understanding.

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

Plan for evaluating and revising the task at the end of the process.

Content knowledge: test tools (students assessment) to measure knowledge competences):

Indicator	Achievement criteria
Fundamental concepts (mathematical ideas at the heart of each activity) Coherent conceptual understanding.	Students imagine the sample space, obtain graphs for an event, independent event. Students are able to generalize activity results to obtain characteristics of probability.

Connections with other content and disciplines and/or real world phenomena.	The task relates to games with a dice.

Procedural knowledge (non-test tools to measure attitude and skill competences):

Indicator	Achievement criteria
Learning motivation (students engaged in thought provoking activities.)	Students work in groups, actively discuss tasks and react at the teacher's questions.

Plan for measure success of the process: Determine how you will know if the process has been successful.

The process is successful when bigger part of the students raised hands to show that they obtained the right solution for each question. And when they actively communicate during generalization part of the task.
In addition, this activity was part of the lecture, so it is more about getting students involved into the process, not much about students evaluating.

STAGE 2: DURING THE INQUIRY
– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Observation	Text notes, checklist, anecdotal report, …
Classroom discussion	Understanding Answer, comments, Learning conversation
Work product	Fulfilled images for the first activity

Implementation and reviewing formative assessment plan.

- Did the students benefit from the activity?
- Did my plan provide the intended effect and results? Why do I think that?
- What changes should I make for better developing students' own understanding?
- Did I select the right time (part of the lecture) for the activity?

2.2. Observations of the Activity Process

Information collected.

Observation	Text notes, checklist, anecdotal report, …
List of purposes of the Unit:	Strength Does inquiry involves the expected?
From student performance data collected:	Nothing was collected from students

Implementation of 'plan for reflecting on the process'.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.
As it was the activity during the lecture, there weren't any evaluation of students.
Review record student notes and formative assessment.

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Adequacy levels: 0 = low; 1 = medium; 2 = High
NA = Not Applicable

Unit opportunities for IBME	Adequacy
Learning contents	2
Topic	2
Aim	2
Place	1
Duration	1
Learner profile	NA
Size group	0-1
Prior knowledge	1
Background experience in inquiry	NA
Additional guidance	NA
Students engagement	2

Scopes (list)	Adequacy
Using the definition of classical probability	2
Replace "?" sign in the formulas using previous results	2
Generalization of all results	2

IBME Competences (list)	Adequacy
Taught prior to the Unit	1
Stressed throughout the Unit	2

Material and resources (list)	Adequacy
Training material	2

Lesson plan		
Activity (list)	Adequacy	Duration

Activity 1	2	2
Activity 2	2	1

Diagnosis plan	Adequacy
Diagnosis plan	2

Formative assessment (plan and implementation)	Adequacy
Plan	1
Implementation	1

Summative assessment (plan and implementation)	Adequacy
Self-assessment	NA
Peer-assessments	NA

Self-evaluation (plan and implementation)	Adequacy
Plan	2
Implementation	1

Evaluating and revising	Adequacy
Plan	2
Implementation	1

Conclusions.

There were 2 inquiry-based exercises at the end of the lecture, after finishing a necessary theoretical part. Students obtained additional printed list for the first exercise. They worked in groups of 2+ people. Approximately one quarter of students worked alone. Students were surprised to have something to do by themselves during the lecture as they are not used to it. But almost every student started to do something, even if not all of them were listening to the lecture before. They were not shy to ask the lecturer for an advice if needed, actively reacted for lecturer's questions. After checking the results students were quite involved into the process of generalization their activity to more universal characteristics of probability.

However, 15-20 people left the class at the beginning or during the work (because that was the last part of the lecture). So, maybe it could be better to move the task somewhere towards the middle of the lecture. On the other hand, especially because this is a lecture, it shouldn't be right decision. For the lecturer and also students it could cause the prolongation of the lecture as it could be harder to continue after active discussions.

In general, that was successful enough attempt of inquiry-based learning.

CASE E: 'Bad questionary'

STAGE 1: BEGIN THE INQUIRY – Setting goals, objectives and task -

1.1. Pedagogic case (onwards Unit) opportunities for IBME

Within the program of studies of the subject and the yearly plan, **entry points and topics** that engage student's interest and involve a problem issue.

Program of studies	Bachelor's degree, all fields of study of the Faculty of Economics and Administration.
Course name:	ESF:BPM_STA1 Statistics 1
Credits/hours:	5 credits
Pedagogic case:	
Topic:	Questionnaire design.
Aim of the Unit:	What to avoid in questionnaire design.
Place of Unit in the course:	The task is proposed at 2nd seminar.
Duration (hours/sessions):	20-30 minutes
Others (For example: mandatory/voluntary …):	The subject is mandatory for the degree.

Background knowledge relative to the Unit and background experience in Inquiry.

Learners profile (orientation, year, age):	Non-mathematicians, 1st semester of the 2nd year study.
Size of the group:	20-30 students.
Homogeneity or heterogeneity of the group:	Heterogeneous (different level of knowledge).
Prior knowledge:	All students had mandatory mathematics at the 1st year of study.
Background experience in Inquiry:	Basically, students did not have any experience in inquiry. There were two kind of inquiry based activities at the first seminar.

Additional guidance for students.

Additional guidance:	Students should try to fill prepared questionnaire with purposely made mistakes.
Special needs:	NO
Other:	Prepared bad questionnaire.

Unit opportunities to engage all students in the class.

At the beginning all students fill the questionnaire along so it could be comfortable even for students who doesn't like to work in pairs. After it there is discussion about every question.

1.2. Scopes

Intended learning scopes (ILS) of the Unit. Scopes must be such that quantifiable criteria can be included.

List of ILS:

- Filling the questionnaire.
- Mistakes' identification.
- Discussion + correction.

1.3. IBME Competences

Previously acquired competences (inquiry skills) of students necessary for the Unit.

None, because students don't suppose to have any experience in inquiry.

Competences (inquiry skills) that can be achieved thorough the Unit.

List of IBME competences (inquiry skills) that will be taught prior the Unit:

None, for all students this could be a first inquiry task.

List of IBME competences (inquiry skills) that will be stressed throughout the Unit:

Students supposed to learn how correctly formulate question for questionnaires.

1.4. Teaching and learning material and resources

Teaching and learning material and resources (print, not-print, digital, multimedia) and ways to share then with students.

List of material and resources (and ways to share them):

- The questionnaire.

Schedule time for students to browse through resources before the Unit so that they become comfortable with resources.

Students start to fill the questionnaire immediately.

1.5. Teaching/Learning activities and timetable

Lesson plan: order in which the Unit will be taught.

	Activity	
	Description	Time
1	Filling the questionnaire Activity 1	< 5 minutes
2	Mistakes' identification	10 minutes
3	Discussion, mistakes' correction, generalization	10-20 minutes

1.6. Plan for monitoring and assessment

Student assessment: Determine how lecturer are going to monitor and assess student progress in both process ongoing basis and learning outcomes.

Plan for diagnosis: Diagnostic assessment provides information about what students know and can do before the start of an activity, and about their individual strengths and difficulties. This information can be used to take decisions (structured inquiry, guided inquiry, open inquiry).

It is the first activity of the seminar, so there were no additional information before.

Plan for formative assessment: Formative assessment provides ongoing feedback about student progress and the effectiveness of instruction (helps to identify and monitor student's development of skills and strategies for planning, retrieving, processing, creating and reflecting during the inquiry activity).

During the activity the tutor walked through the class, communicated with groups.

Plan for summative assessment: Summative assessment provide information (for students and teachers) about achievements on the inquiry activity and learning outcomes.

Moderated discussion.

Plan for student self-evaluation.

Students had chance to evaluate their thoughts during the discussion.

Activity assessment.

Plan for reflecting on the process: For each stage and step of the lesson plan determine what students have learned, what need to learn and how the process is going.

Plan for evaluating and revising the task at the end of the process.

Content knowledge: test tools (students assessment) to measure knowledge competences):

Indicator	Achievement criteria
Fundamental concepts (mathematical ideas at the heart of each activity) Coherent conceptual understanding. Connections with other content and disciplines and/or real world phenomena.	Students could find mistakes in questionnaires. Students could create correct questionnaires. The task relates to all types of questionnaires which could appear in any field of real world.

Procedural knowledge (non-test tools to measure attitude and skill competences):

Indicator	Achievement criteria
Learning motivation (students engaged in thought provoking activities.)	Students work along or in pairs/groups, actively discuss possible mistakes and react on the tutor's questions.

Plan for measure success of the process: Determine how you will know if the process has been successful.

The process is successful when all students start to work with the questionnaire and try to think what is wrong with some questions. And when they actively communicate during discussion. In a long perspective, the activity will be successful when students will prepare better questionnaires for their bachelor and master theses.

STAGE 2: DURING THE INQUIRY

– Observe and collect data – Implementation of plans for formative assessment and reflecting on the process -

2.1. Observations of the Students

Information collected.

Observation	Text notes, checklist, anecdotal report, …
Classroom discussion	Understanding Answer, comments, Questioning
Work product	Activities completion and time Use of materials and tools

Implementation and reviewing formative assessment plan.

- Did the students benefit from the activity?
- How did I moderate the activity?
- How did I react on unexpected questions?
- How right did I use good answers and propositions?

2.2. Observations of the Activity Process

Information collected.

Observation	Text notes, checklist, anecdotal report, …
List of purposes of the Unit:	Strength Does inquiry involves the expected?
From student performance data collected:	Nothing was collected from students

Implementation of 'plan for reflecting on the process'.

STAGE 3: AT THE END OF THE INQUIRY
– Student assessment – IBME activity assessment and reflection -

3.1. Student assessment

Comprehensive and criteria-based assessment.

As it was the activity during the lecture, there weren't any evaluation of students.

Review record student notes and formative assessment.

3.2. IBME activity assessment and reflection

Summary, analysis and evaluation.

Adequacy levels: 0 = low; 1 = medium; 2 = High
NA = Not Applicable

Unit opportunities for IBME	Adequacy
Learning contents	2
Topic	2
Aim	2
Place	2
Duration	2
Learner profile	2
Size group	2
Prior knowledge	NA
Background experience in inquiry	NA
Additional guidance	NA
Students engagement	2

Scopes (list)	Adequacy
Filling the questionnaire.	NA
Mistakes' identification.	1
Discussion + correction.	2

IBME Competences (list)	Adequacy
Taught prior to the Unit	NA
Stressed throughout the Unit	1

Material and resources (list)	Adequacy
Training material	2

Lesson plan		
Activity (list)	Adequacy	Duration
Activity	2	1

Diagnosis plan	Adequacy
Diagnosis plan	1

Formative assessment (plan and implementation)	Adequacy
Plan	1
Implementation	1

Summative assessment (plan and implementation)	Adequacy
Self-assessment	1
Peer-assessments	2

Self-evaluation (plan and implementation)	Adequacy
Plan	2
Implementation	1

Evaluating and revising	Adequacy
Plan	1

Implementation	1

Conclusions.

The task was the first activity of the seminar. The questionnaire engaged students' attention. At the beginning they were surprised with personal questions, then it was a bit uncomfortable for students to answer. After tutor told there are mistakes students started to work harder, partially in pairs. According to the tutor feelings the activity was productive, the tutor was mostly passively listening to students' talks and ideas. During evaluating there were discussions about some questions from the questionnaire, if some of them are questions at all, if context matters. So, after this activity students obtained useful recommendations for creating questionnaires which could be used for bachelor and master thesis.