Training module:
Teacher guide for inquiry-based learning in Vocational Education and Training

BARCOVE
BUILDING AN APPLIED RESEARCH FACILITY INTO

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Introduction

This training module is a guide for projects following the pedagogy of inquiry-based learning in Vocational Education and Training (VET). Teachers can make use of this module in order to direct the execution of projects as described in the thematic chapters or for one's own theme. We demonstrate how a project can be formed based on the seven phases of inquiry-based learning. The extent to which a teacher uses this guide as either a step-by-step instruction or as a source of inspiration is entirely dependent on the knowledge, experience and need of the teacher.

BARCOVE's mission is to establish a model of school-company cooperation that sets a new standard in VET. This module supports that goal by enabling teachers to create inquiry-based learning experiences that connect classroom knowledge with real-world industry practices. Through inquiry-based projects and collaborations, students gain practical insights and skills that enhance their readiness for the workforce.

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Chapter 1: Project Preparation for the Teacher

A successful inquiry-based learning project should be prepared thoroughly. Here we mention several key points that are associated with a good preparation.

Immerse yourself in the theme

A project starts with selecting a theme. It is important to take time to make the introduction of the theme yourself before you can introduce it to you students.

Know the pedagogy of inquiry-based learning

In order to properly guide students through their research, you require knowledge about the pedagogy of inquiry-based learning. It is, hereby, important to both know the seven phases that the students must proceed through, and to know how to guide the students through this process. Didactic knowledge is necessary in order to know how to guide your students during the execution of their research projects. What makes a particular question a good research question? What should students pay attention to while setting up their research? How can you ensure that 'fair research' is performed, implying that only one variable is varied? How can students draw valid conclusions based on the information they have collected? In this chapter, we describe the entire process including instructions on how to guide the students.

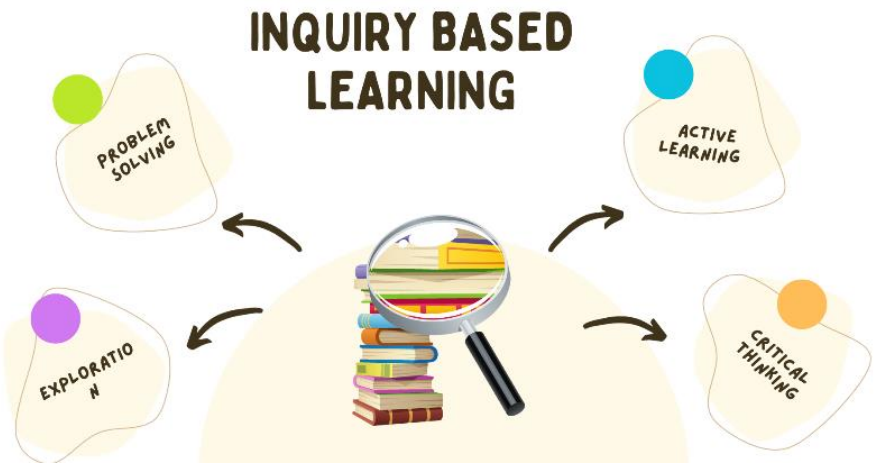

Figure 1. The fundamental basis of inquiry based learning

Construct an overview of the entire project

Ask yourself questions like:

- How many lessons time will you devote to the project and their several phases?
- Do your students work only during the regular lessons on their project, or do you give them extra time during independent work time?

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By answering these kinds of questions and creating a plan of the entire project you will avoid unfavorable surprises. Experience shows that if the teacher possesses a good overview of the project, then the students too will have a clear idea of what is required of them.

Keep both your experience and that of your students in mind

For many teachers, inquiry-based learning is a new way of teaching. A project inquiry-based learning can seem like a big step, especially for teachers who are not accustomed to giving students a lot of responsibility regarding their own learning. Inquiry-based learning should be considered a learning process in which mistakes can be made for crucial skills, such as formulating a good research question, it might be useful to devote a lesson to those skills outside the domain of the students' research projects.

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Chapter 2: Teacher´s Guide to the Phases of Inquiry-Based Learning.

The pedagogy of inquiry-based learning that we use here is based on the seven phase model by Van Graft and Kemmers (2007). The seven phases provide guidance to the project, and it forms a parallel with research because it is based on the (empirical) cycle that scientists proceed through. Research is, therefore, seen as a cyclic process: questions that are answered by research often generate follow-up questions leading to the reiteration of the process.

Figure 2. The seven phases of inquiry based learning

For every phase, we describe the goals, the activities for the students and how the teacher can provide guidance for this process.

2.1 Introduction

When it comes to inquiry-based learning, it is essential that a learning environment is created in which students can fulfil the role of a researcher and can conduct research. At the start of the project, you introduce the theme and the way in which the students should work.

Goals of this phase:

- Students become curious about the theme.
- Students activate their prior knowledge.
- Students are introduced to (scientific) research.

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Guidelines for the teacher

- **Introduce the theme with an activity.** On the basis of one or more meaningful activities that match their experiences, you can pique their curiosity about the theme. This activity is not intended for them to gain knowledge, but rather to trigger their curiosity and raise questions. In the thematic chapters, activities are described that can be implemented to achieve this purpose.
- **Activate prior knowledge**. Before the content of the theme is explored, it is important to activate the prior knowledge of the students. One way is to have the students create a mind map to illustrate what they already know about the topic. If the students expand their mind map over the duration of the project, it can be used as a visible means of monitoring their increase in knowledge.
- **Encourage the asking of questions**. Students often find it difficult to ask questions. Some perceive it as an embarrassing act, because by asking a question they display they do not know something. For scientists, however, wanting to know is more important than actually knowing. Whoever asks a question wants to know something and can conduct research. It's very simple; without questions there is no research. To achieve this state of mind in students, the act of asking questions should be appreciated and encouraged. As a teacher you should act as a good example by constantly being curious and wondering aloud.
- **Construct a question wall in the classroom**. During the project, you want to make sure that the students' questions about the theme are not overlooked or lost. Therefore, it is recommended to introduce a 'question wall'. Such a wall can be given shape and form in a variety of ways: for example, by hanging two large sheets of paper on the wall with at the top: 'What do we want to know?' and 'What do we already know?'. The students can then write down and stick their questions on there for the duration of the project.

Figure 3. Example of a question wall placed in the classroom

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2.2 Exploring

Exploring is essentially when the substantive basis for the project is established. It is during this phase that ideas for research projects are generated by the students.

Goals of this phase:

- Students activate their prior knowledge.
- Students expand their knowledge about the theme.
- Students acquire inspiration on ways of doing research on the theme.
- Students ask many questions about the theme.

Guidelines for the teacher

- **Ask many questions**. Also, during this phase is it important to address the prior knowledge of the students. In addition, by questioning the students, their thought process maintains an active state so that they can get acquainted with the theme. Explain the theme to the students before the students explore the theme through activities, it is good to provide them with a contextual framework. You can spend a lesson to explain the theme, possibly with the aid of films or other media.
- **Choose a number of different activities**. A theme is best explored by using a multitude of different activities. By using different activities, students acquire concrete experiences from different perspectives and gain knowledge about the theme and about the research that scientists conduct within that theme. Going on a fieldtrip, guest lesson from a professional from the field, having an interview, analyzing an article are good examples.
- **Establish the connection between activities and the theory**. The goal of the activities is to gain knowledge about the theme. To ensure that knowledge is well received by the students, it is important to explain how the activity is related to the theme and what can be learned from the activity about the theme. This should be done prior to the activity. In concluding an activity, you should always affirm what the students have learned about the theme, whereby you have the students identify the connection between the activity and the theme before telling them yourself. This way the knowledge learned becomes more embedded.

Figure 4. Fieldtrip with an expert

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2.3 Designing Research

During this phase, the research question is determined. The research question is central to the entire research, making this particular phase a very important one. For students and teachers, this proves to be one of the more difficult components of the inquiry cycle.

Once the students have formulated a suitable research question, they can then begin creating a corresponding research plan. Sometimes students prefer to start immediately with their research and do not see the purpose of coming up with a concrete research plan. Nevertheless, it is important that they take the time to think about the details and create a research plan.

Goal of this phase:

- Students learn to formulate a question that is researchable by them.
- Students properly prepare their research.
- Students develop their question into a research plan

Guidelines for the teacher

- **Familiarize the students with the criteria of a good research question.** Formulating a question that is researchable is, both for the teacher and for the students, one of the most difficult aspects of inquiry-based learning. If the students have no experience with research questions, we recommend devoting a separate lesson to familiarising the students with the criteria of a good research question. This can be done by practicing with example questions.
- **Have the students formulate their own research question.** Once the students are familiar with the criteria of a good research question, they can begin with formulating their own research question. The questions that first arise are often not yet directly suitable for research. The trick is to transform the unpolished and unsuitable questions into questions that can be researched. It is the task of the teacher to assist the students in this process.
- **Learn to recognize different types of questions.** Students pose all sorts of different questions about the theme. It is interesting to take a closer look at the type of questions and to give the students insight into the different types of questions that exist. Can the students classify their own question? You can spur them on to come up with a different type of question using this knowledge. Examples of different types of research questions:
    - Counting and measuring questions: These questions look to keep track of amounts or measure something. Examples include ‘How many students in our class are colour blind?’ or ‘How high is the tallest sunflower in our class?’.
    - Rating questions: With these questions, you acquire insight in how people value things. Examples include ‘What do the students in our class prefer to do in their free time?’ or ‘What smell do the students in our class consider the worst?’.
    - Comparison questions: Here the focus lies in discovering the differences and similarities. Examples include ‘Which paint is easier to apply to a sheet of paper: paint that has been heated, paint that has been chilled or paint at room temperature?’ or ‘Are the workers from EQF level 2 more stressed when seeing or holding a mealworm then the students of EQF level 4?’.
    - Consequence questions: These are questions whereby you manipulate something and research the consequences of the manipulation. Examples include ‘What happens to your weight when in a moving elevator?’ or ‘What

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changes do you perceive in the pattern of colliding sound waves when you block the sound waves by placing a large object in the room?'.
    - Relationship descriptive questions: Sometimes you want to know how two things are interrelated. Examples include 'What is the relationship between water temperature and the speed at which you can swim?' or 'What is the relationship between the frequency of washing your hands and the amount of bacteria present on your hands?'.
    - Experience questions (phenomenological questions): These questions look to understand how people perceive a certain situation. Examples include 'How would students in our class experience a four day period without internet and screens (tv, tablet, telephone)?' or 'When do people really feel part of a culture?'.
    - Opinion questions: Here you ask about people's views and arguments. Examples include 'Do the students in our class think that the task of the teacher can be taken over by a robot?' or 'Do the parents of the students in our class think pictures and videos of their children can be distributed on social media without their permission? Why/why not?'. The above list is not exhaustive; there are still other types of questions imaginable. Questions can often be a combination of different types.
- **Have the students to set up a research plan.** The students describe what needs to be done in order to answer the research question. Who are the students going to research? How are they going to approach it? Who is going to do what and when? How are they going to record the results? The students also make predictions about what the answer might be: they formulate the hypothesis.
- **Have the research plan approved before the research is conducted.** It is important to inform the students that they can only start the execution of their research after you (in collaboration with the company or assignment giver) have approved their research plan. Based on their research plan, you will have an overview of what their intentions are and what they have not yet considered. In this way, you remain one step ahead of them.

Research Question	Hypothesis	Research Objectives
A research question is a clear and focused question that guides your research. It identifies the specific aspects of a topic that you want to explore and sets the direction for your study.	A hypothesis is a testable statement that predicts the relationships between variables. It is based on existing theories and knowledge and serves as a foundation for testing and validation through scientific methods.	Research objectives are the specific goals that your research aims to achieve. They provide direction and focus, help structure your study, and ensure that it addresses relevant issues effectively.

Figure 5. Key Elements of the Design Research Phase

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2.4 Conduction Research

During the execution of the research, students should work as a group as much as possible. You must ensure that you have an overview of what the groups are doing and that you always remain one step ahead of them so that you can intervene promptly when necessary.

Goals of this phase:

- Students learn to independently perform their own research.
- Students learn to work together as a group.

Guidelines for the teacher

- **Let the students start on their own**. Once the research plan has been approved, the students are prepared to carry out their research. They know who they are going to research, how they are going to do it and what they need. You can now let the students work independently. By allowing the students to feel ownership of their own research, many groups may surprise you with their results. This does not imply that your supervision is not necessary, however.
- **Be one step ahead of your students**. Even though your students have to conduct the research themselves and are responsible for it, it is wise to anticipate potential problems. You can anticipate these problems by viewing their research plan and deducing possible factors they have not yet considered.
- **Have the students keep a logbook**. Doing research requires students to work in an organized way. Keeping a research logbook is one way of doing this. The logbook can be filled with descriptions of how the research is conducted and any unexpected events that may have occurred that could be of influence on the results. The groups should also record their experiences during the project, what they have learned, any questions they have, what obstacles or difficulties they encountered, the role each member fulfilled, the agreements that were made within the group and the data collected. The logbook will help them to reconstruct the phases of their research and may help them devise explanations for their results.

Figure 6. A logbook is essential to keep the research organized

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2.5 Concluding

With the completion of the execution of the research, the results must be clearly processed and displayed, for example in a table or graph. Based on the results, the students should then draw a conclusion: the answer to their research question.

Goals of this phase:

- Students get an overview of the results they collected during the execution of their research.
- Students establish the link between the results of their research and their research question.
- Students can concisely articulate the results of their research (conclusion)

Guidelines for the teacher

- **Teach the students to distinguish between the results and the conclusion**. Results are slightly different than the conclusion. Because the distinction between results and conclusion is often difficult to make for students, we recommend devoting some attention to this in advance. In short, the results can be made comprehensive by displaying them in a graph, table or pie chart. In describing the results, you indicate which results stand out. This phase of concluding is the about analyzing. The conclusion is essentially the answer to your research question.
- **Have the students reflect on their conclusion**. Once the conclusion has been reached, the students interpret and compare it to their hypothesis (the prediction). The worksheet presents a number of questions that are meant to assist the students in this process. Is the students' conclusion the same as their hypothesis? Why/why not? Why do the students think that these results and conclusion were found? Did any surprising elements come forth from the research? What would the students do differently if they had to redo it?
- **Have the students understand that conclusions are always temporary**. Have students get familiar with the idea that the conclusion of a research is always temporary. There is always a possibility that subsequent research debunks the results or the interpretation of the results. This is simply how science works. Sometimes a conclusion can stand undefeated for tens or hundreds of years to ultimately be changed following new research. Hence the knowledge that we have is continuously changing! Research and knowledge are never finished.

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When is your heart rate higher: standing or lying down?

Results
When 'standing', a heart rate of 82 beats per minute was measured on average. When lying down, an average rate of 63 heart beats per minute was measured.

Conclusie
The heart rate is higher when standing relative to lying down.

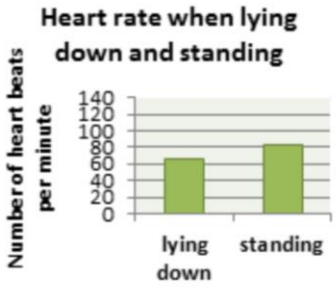

Figure 7. Example of a research question

2.6 Presenting

The presentation is an important part of research, because it gives an overview of the entire research process. It requires the students to look back on the entire process.

Goals of this phase:

- Students learn to create an overview of their research as a process and of their results.
- Students reflect on the process, the results and the conclusion of the research.
- Students learn to explain the process and the results in a clear and structured way.
- Students learn to come to an agreement together about the form and content of the presentation

Guidelines for the teacher

- **Tell the students what they should tell in the presentation.** The students must clearly give an overview of how they started from their research question and how they ultimately arrived to their answer. You can ask the students what they think should be addressed during a presentation in order to provide the audience with a clear image of the research. The following components should be addressed in a presentation:
    - Introduction
    - Research question
    - Predictions or hypothesis
    - Research plan
    - Execution of research: how was the research stepwise conducted?
    - Results
    - Conclusion
    - Improvements and reflection on the research and its process
    - Time for questions

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- **Have students decide for themselves how to present their research.** The students are usually strongly committed to their own research and are also very proud when given the chance to present their research. Let them do so in a creative way, for example in the form of a PowerPoint presentation, a field trip, a poster, a demonstration of their research, a theatre piece, a film, an article in the school paper, a vlog. By giving students, the autonomy to make their own decisions, , you give them the possibility to come up with a multitude of creative ideas. That being said, the purpose remains that they present their research and its important components.

Figure 8. Students present their research in different ways

- **Invite an audience to the presentation.** Often there are stakeholders involved in research within Vocational Education and Training. For example: people from companies, municipalities, other students, experts etc. Invite those people for whom the research is relevant or interesting.

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2.7 Deepening and Broadening

The last phase involves the deepening and broadening of the topic. This is an important phase, because the learning gains are solidified and enhanced. The learning gains are solidified by collectively reviewing the process and knowledge gained. In addition, possible follow-up questions are also addressed. The learning gains are enhanced at this stage by offering additional knowledge on the topic.

Goals of this phase:

- Students reflect collectively on their research process.
- Students solidify their learning gains by collectively reviewing.
- Students learn from each other by integrating learning gains.
- Students add prior knowledge with new knowledge together.
- Students end the project together.

Guidelines for the teacher

- **Integrate new knowledge with existing knowledge**. It is good to reflect and think about the amassed knowledge after all research projects have been presented. What did we all know already (prior knowledge) and what have we learned since then by looking at existing knowledge (exploring) and through our own research? What have all the research projects provided? By discussing this with one another, the different learning gains are reviewed, and the students are given the opportunity once more to learn from each other.
- **Add new knowledge.** Now that students have actively immersed themselves in the theme and have conducted their own research, their knowledge can be further broadened by supplementing it with existing knowledge. This can be achieved by hosting an additional lesson on the theme, or to go on a field trip that is relevant to the topic.
- **Evaluate the project and end it together.** Following the presentation, the different groups all reflected on their research process. By mentioning the phases once more and collectively looking at what went well and what can be improved for next time, the students can benefit from each other's learning moments. This applies to both learning moments where things went well and where things went less well. Some questions that you can ask at this point include: What went well? What can we do better next time? What was the most fun to do? How was working together? Would new agreements and arrangements have to be made if we were to repeat a project inquiry-based learning?

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Figure 9. A teams evaluation moment with students, teacher and the company

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Chapter 3: The Role of the Teacher during Inquiry-Based Learning

It is essential that teacher creates a good environment for inquiry-based learning. We provide the following advice in achieving this.

Display yourself as a coach

As a teacher, it is your task to provide the students with the necessary basis for inquiry-based learning. In addition to this, you should display yourself as a coach and facilitate the learning process of students where needed. You are not expected to know the answers to all the students' questions. It is more important that questions are actually being asked and that a collective effort is made to search for an answer.

Dare to let go and allow students to be responsible for their own learning process

The transition to a role as coach requires that you dare to let go and to allow your students to work independently on their research. It is important that your students can acquire experience by themselves and attain a feeling of responsibility for their own learning process. This implies that you must be willing to hand over the control; you must dare to let go so that they can conduct research. Gradually you will have to retreat from your role as content expert and the students will continuously learn how to better collaborate. Doing this will allow students to continue becoming more independent.

Be a role model

The manner in which you convey your inquisitive attitude has great influence on that of the students. Provide a good example and adopt an inquisitive and critical attitude. It is more important to ask questions than to have the correct answers. The need to know and the search for an answer is the core of your teaching practice. If you display an inquisitive attitude, your students are bound to adopt it as their own.

Figure 10. Teachers play an important role as coaches and role models

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Chapter 4 Hybrid learning environment, working on real assignments together with companies

As indicated in Chapter 3, the role of the teacher or supervisor in getting students to work in an investigative manner is very important. In the case of BARCOVE, students work on real assignments together with companies. This can be seen as what is so-called a hybrid learning-work environment (Bouw et al., 2021).

In a hybrid learning environment where educational institutions collaborate with companies on research assignments, the teacher or supervisor plays a crucial role in training agile professionals. The lecturer acts as a link between education and practice, supporting students to apply theoretical knowledge directly in real business contexts. They facilitate a learning environment that focuses on flexibility and adaptability and encourage students to think independently and problem-solve. In doing so, the instructor monitors both the learning objectives and the quality of the research results, ensuring a good balance between guidance and independence. All this contributes to developing practical skills and a mindset that matches the dynamic needs of the job market.

Research into the mechanisms involved in mentoring within environments, where students and companies collaborate on applied research, has been conducted by Bianca Dusseljee and Marco Mazereeuw (2022). Figure 1 illustrates the characteristics that play a role in the learning environment and how mentors can intervene within these environments.

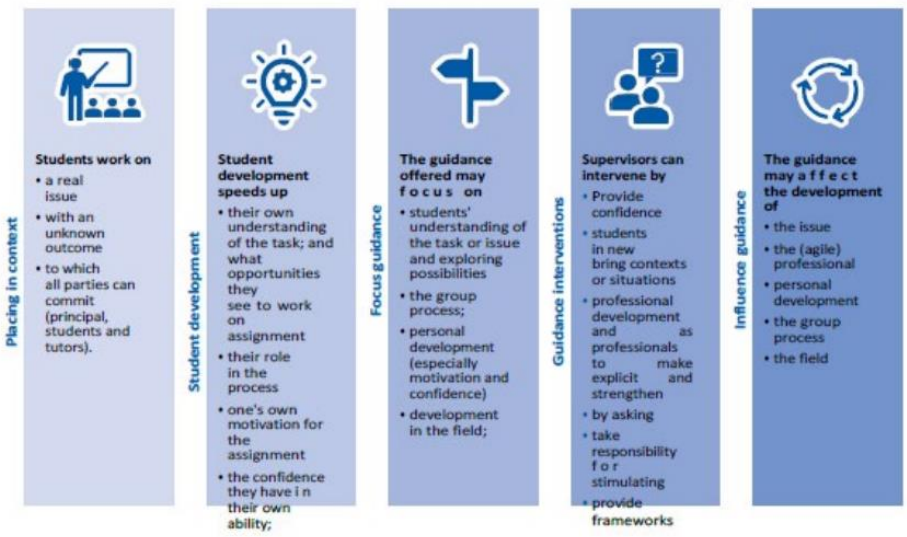

Figure 11. Characteristics of guidance on agility in CIV Water learning environments (Dusseljee, and Mazereeuw)

These environments aim to develop students' professional agility, or their ability to adaptively and proactively improve both their work and professional growth.

The main mechanisms as mentioned in these articles are described below.

***'Context Placement & Mentoring Focus** If you want to guide students in their development of professional agility in a hybrid learning-work environment, you are advised to have them collaborate on a real-life issue where the outcome is not predetermined, and both students and mentors and clients can commit to it.'*

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*‘**Development of students & guidance interventions** If students are not being addressed on their professional adaptability or seem to be insufficiently development-oriented and explorative in their actions, you are advised to intervene focusing on the students' development.’*

*‘**Group process** If you as a guide notice that students have difficulty cooperating and as a result are not developing in terms of the issue or themselves, you are advised to focus the guidance on the group process.’*

***’Motivation** If you, as a guide, notice that the students are not motivated to develop the issue, the group process, or themselves, you are advised to focus the guidance on taking responsibility for their own development and to encourage them to think about what a feasible and desirable step in their development would be.’*

***‘Trust** If you, as a guide, notice that the students have too little confidence in their own abilities or the ability to develop themselves, you are advised to focus the guidance on that.’*

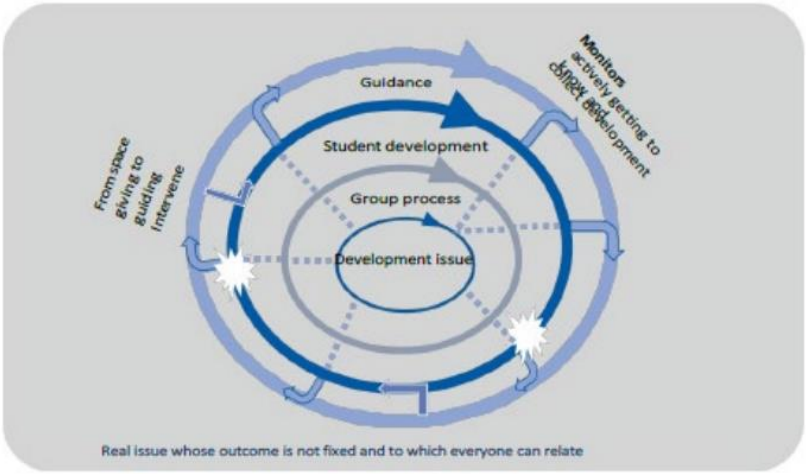

Figure 12. Mechanisms for guiding professional agility in students (Dusseljee, and Mazereeuw)

In a webinar by Marco Mazereeuw (https://www.linkedin.com/in/marco-mazereeuw-26661416/), these mechanisms were explained and discussed with teachers and companies involved in the BARCOVE project.

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