

## Detailed project description

"Jana in the Everglades - Separation Methods for on the Go" is a teaching project that was developed and tested by the SINUS group "Chemistry Teaching in Highly Heterogeneous Learning Groups" for the introductory teaching of chemistry (NRW: Year 7). The special feature of this working group is that it is made up of teachers from different types of schools (Gymnasium, Realschule, Hauptschule and Förderschule) who have had completely different experiences with heterogeneous learning groups and who have contributed their expertise to the development of the teaching material.

The principles and guidelines for planning common lessons according to the Universal Design for Learning (UDL) were taken into account when creating the teaching materials. This is an approach to instructional design that seeks to enable all learners to learn successfully (CAST, 2011), while

- Providing flexibility in the presentation of information, in the presentation and demonstration of knowledge and skills by learners and their activation and motivation,
- reducing barriers in teaching and providing appropriate spaces, supporting and challenging and maintaining high performance expectations for all students in a learning group (Schlüter, Melle, Wember, 2016). This means that lessons are designed through flexible learning strategies and variable material design in such a way that not only students with impairments, but all learners in a learning group can benefit and learn successfully (for the guiding ideas and principles of UDL, see Meyer, Rose, Gordon, 2014).

The teaching project was implemented in the form of a digital learning environment with which all relevant separation methods can be worked out independently by the learners. It covers all the competency expectations required in the core curricula for Hauptschule, Realschule Gesamtschule and Gymnasium (MSW 2008, MSW 2011, MSB 2019) with regard to the main content area of separation methods and is also suitable for pupils with learning difficulties thanks to a comprehensive range of differentiation measures. The special focus of the project is on the development of competencies from the competence area of knowledge acquisition, because all experiments are planned, carried out and evaluated independently by the learners after they have identified the problem and developed a suitable problem question. The project comprises six lessons. First, the different separation processes are worked out in order of increasing complexity (sorting/sifting, sedimenting/decanting/filtrating, extracting, distilling). Finally, the learners have to use their knowledge to separate a multi-substance mixture in a target-oriented way. Different procedures are possible. Practical experience shows that different groups of students actually develop different solutions.

### Core Concept of the Lessons:

All lesson units follow the same pattern and revolve around Jana, who is on the go in the Everglades and who is constantly having mishaps that can be fixed with the help of separation methods.

Each lesson begins with an excerpt of a text message between Jana and one of her friends in which she reports her mishap and asks for help (see Fig. 01\_Example-Chat.jpg). This message is used to introduce the learners to the problem. Together with the learning group, a research question is formulated, the solution of which should help Jana to solve her problem. For this purpose, the learners are to independently plan an experiment in groups for the corresponding separation of substances. To make sure that the learners also plan purposefully, a flow chart containing the necessary separation steps and the subsequent results must be filled in before the experiment is carried out. Different material boxes (a box for professionals or a box designed to grow with the students) are available to the students as further planning aids. Afterwards, the experiment is carried out and evaluated according to their own plans. Finally, the learners write an answer to Jana in their groups and give her a tip on how to solve her

problem. However, since Jana does not have a chemistry lab with her on her trip to the Everglades, the suggestion for solving the problem must be feasible with materials from Jana's backpack (see Fig. 02\_Jana's backpack.jpg, 03\_Pupil solutions.jpg). For this, the pupils have a picture of the contents of the backpack and a list of the things she carries with her. To back up what they have learned, the learners fill out a page of a buddy book at the end of each lesson or as homework, so that at the end of the project each student has an overview of all separation methods in written form (see Fig. 04\_Buddy\_Book\_Safety.jpg).

#### Differentiation modules:

In order to enable all learners of a heterogeneous learning group to successfully work on the task independently, various differentiation modules were developed for the planning and implementation of the separation experiments.

Different material boxes are available to the pupils for planning the experiment. They serve as a structuring aid and facilitate self- and work organisation. For low-performing pupils and those with a learning focus, only those materials are in the box that are needed for a meaningful problem solution, i.e. these pupils get their own material box for each separation task. Alternatively, the box can grow with the pupils, i.e. the materials needed for solving the new problem are added. More advanced learners, on the other hand, get the so-called professional box right from the start, which already contains the equipment and chemicals for all six separation tasks and from which they have to select the appropriate materials for their plans in each case.

There is a template to help them fill in the flow chart. In addition, an explanatory video is available in which the example of the separation of a mixture of iron and sand is used to show step by step how to fill in the flow chart. In addition, learners, especially those with learning difficulties, can refer to a completed example (see Fig. 05\_Tippkarte\_Flussdiagramm.jpg).

In addition, learners can make use of graduated help for planning and carrying out their experiment. The first help ("Think about which materials you need and which you don't.") is a strategic help, which should encourage the learners who have chosen the professional box to take a closer look at the equipment and chemicals provided. The second aid is a set of index cards describing the different separation processes and indicating which substance property they are based on. These cards help to choose the appropriate method (see Fig. 06\_Tip card\_separation methods). Layout sketches for the different separation processes serve as visual support and facilitate action planning during experimentation. The third aid goes one step further and suggests the materials needed. In this way, a possible path is implicitly given even for pupils with learning difficulties. For learners with a great need for support in the area of cognitive development, the last possible help is a complete set of experimental instructions, which can be supplemented by a sketch of the set-up (see Fig. 07\_Tipcard\_Experimental Instructions).

#### Implementation in a digital learning environment:

Due to the many differentiation possibilities, the effort required to prepare the teaching project (different material boxes, different sets with graduated aids or aids to fill in the flow chart, possibility to play the explanatory video) is very high for the teacher. In addition, the practical implementation showed that many pupils with cognitive impairments are overwhelmed with the selection of suitable aids, especially with such a variety of help options. Therefore, the teaching project was implemented in the form of a digital learning environment with PowerPoint. All working materials for planning and carrying out the experiments, including the introductions to the various separation methods, are made available to the learners digitally and are accessible through links (see Fig. 08\_Estiegeseite\_Lernumgebung.jpg). The central element of the learning environment is a checklist, with which the procedure is presented transparently and to which all aids lead back again and again (see Fig. 09\_Checklist\_learning\_environment.jpg). The combination of digital learning environment, experiment boxes and graded help cards supports multi-channel learning, because they combine visual and verbal information and enable

learning by doing. Further advantages of the learning environment are that the learning aids can be viewed individually by the pupils as needed via links (see Fig. 10\_stepped\_helps\_learning\_environment.jpg).

The fact that with the digital learning environment all learners can work according to their learning pace, however, also has the consequence that not all pupils can carry out all separation procedures. Here, within the framework of a further differentiation measure, a choice must be made as to which of the procedures must be carried out by all pupils and which are available for free choice. The decision depends on the heterogeneity of the learning group and must be made specifically for each learning group.

First experiences with the use of the digital learning environment show that after an introduction to the handling, the pupils are highly motivated and can work very independently with the materials.

Note: The illustrations in brackets refer to the separate picture appendix.