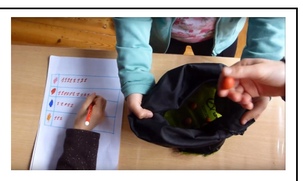
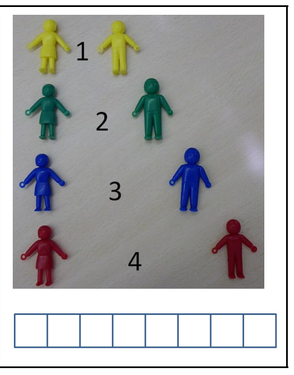
The vidumath matrix

The matrix provides an overview. It has two dimensions.

- The first dimension is the **video production level**. We provide *entry*, *intermediate* and *advanced* video production examples. These levels are not based on mathematics levels. There is a range of production levels from beginners to advanced video producers. The levels also build on each other. The knowledge acquired with the entry task can be applied to the intermediate task, and the knowledge acquired with the intermediate task can be applied to the advanced task.
- The second dimension is the mathematics **learning opportunity**. We provide examples for *introduction*, *problem solving* and *consolidation*. These are not levels of difficulty but parts of the learning process. vidumath can be used either when introducing a new topic or when students solve a mathematical problem or to examine or consolidate students understanding.

Learning opportunity

Video production level

	Introduction	Problem solving	Consolidation
	When we learn something new, we don't start as blank slates. Children always have some experience already, ideas and concepts related to the new topic. In order to build new knowledge from prior knowledge the teacher has to find out what the students already know and belief about the new topic. According to constructivist learning theory it is best for learners to discover facts and relationships by themselves. Students are more likely to remember concepts and knowledge discovered on their own than facts they have only heard or read. vidumath provides an engaging way for the learner to draw on his or her own past experience and existing knowledge to discover facts and relationships and new truths. To do so, we introduce a new topic by giving a discovery task to the students. Students will then produce videos that show how they interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments.	Problem solving plays an important role in mathematics, and hence in mathematics education, too. As *Principles and Standards* (NCTM, 2000, p. 52) state: "Solving problems is not only a goal of learning mathematics but also a major means of doing so." What is considered a real problem and not only a task depends on the students' knowledge and skills. The famous mathematician George Pólya has outlined four steps for problem solving: 1) Understanding the problem 2) Devising a plan how to solve the problem 3) Carrying out the plan 4) Looking back, evaluating if the problem is really solved, reflecting the process These steps correspond very well with the steps of a vidumath project: Making a storyboard for video production helps the students to plan how to solve the problem. Then they take a video that shows either how they carry out the plan or it visualises the solution. Finally, students look back and reflect the process when watching the videos.	Mathematics is a subject where new knowledge to a large degree builds on previous knowledge. If a student forgets parts of the concepts, algorithms, procedures or conclusions learned previously, he or she has no way to build on the learning. Insisting that students consolidate their learning provides critical scaffolding to help them internalise knowledge and skills, enabling them to extend, build on, transfer and apply their understanding. Students have to process the material provided thus far and make sense of it. Otherwise, students are left trying to learn the teacher's thinking instead of making the learning their own. Taking the time to have students summarise and synthesise is the key to teaching for transfer.
Entry task **Screen recording / one-shot video** ♦ **Production:** Recording video in one-shot – without any video editing. ♦ **Possible mathematics content:** This can include anything that takes place in a mathematics classroom or even the documentation: It could be short excerpts of a mathematics situation; It will show one short idea / expression; … The entry task offers a low barrier to entry so that motivation and confidence is raised to try video education. If you have no experience then it is vital to start with very basic exercises. Entry tasks require very little technology understanding. They can include still and moving images. Entry tasks don't include video editing. The recorded material is used as it is.	The entry task can be used to introduce a wide range of mathematics topics. It starts in **kindergarten** with for example the topic two-dimensional geometric shapes. The children get the task to explore their neighbourhood and take still images which show where shapes are featuring for example on furniture, buildings, and traffic signs. Another topic is numbers. The children take still images which either show numerals, e.g. numerals on signs or numbered objects, or they take pictures of sets with a given amount of elements. In **primary school** the introduction of mathematical operations like addition and subtraction is important. When introducing addition for example the students can use the task to find an additive situation and then produce a one-shot video about it. Other topics that suits primary school are quantity of liquids and weight. Students could make a one-shot video that shows how they measure quantity and weight while they prepare a meal. In **lower secondary school** fractions is an important and difficult topic. To introduce the topic, students can use the task to discover how fractions are used in everyday live and produce a one-shot video that shows what they found. Probability is a difficult topic, too. It helps students to discover what it is about when they produce a video of playing a game of chance, such as snakes and ladders and the rolling dice.	The one-shot video technique is suitable for all problems that can be solved either in a straight forward way or by trial and error, and do not require an advanced dynamic visualisation. We tried the following problem with grade 4 children in Coimbra: *https://youtu.be/TFfdAQmq6Io* You have a bag with six balls inside. The balls have four different colours. Find out what colours and how many balls of each colour are in your bag. It is not allowed to look inside the bag or to take out more than one ball at a time. You can take out one and put it back into the bag as often as you want. 	The entry task is especially appropriate for **summarisation**. Summarisation is the restating of the main ideas one has learned. It can be done in writing or orally, but as well through drama, art or music – exactly what vidumath offers. Summarising is a very powerful learning strategy because it requires understanding the material in order to summarise it. The students have to repeat the content to refresh their understanding of the main points. When making the storyboard, students have to distinguish between the fundamental ideas that must be included in the video and which parts can be omitted. And they have to find their own pictures to visualise the mathematical concepts and procedures. That works for almost every mathematical topic.
Intermediate task **Stop-motion (animation)** ♦ **Production:** Stop-motion is a basic type of video animation where still images are put together in a software app or video editing software. Objects are moved slightly and a still image is taken after each motion. The images are put on a video timeline with a short duration between each – and they will start to move automatically. The video is like a cartoon. Stop-motion is a wonderful introduction to the idea of "moving" images. ♦ **Possible mathematics content:** Stop-motion is especially suited for mathematics content where animation works well: showing symmetry; explaining fractions; explaining shapes; … The intermediate task introduces video production. The key difference is that still and moving images and audio are edited. We have chosen stop-motion as the key intermediate example since it is a playful activity but also an activity which can be done nicely without the children appearing in the video or hearing their voices (which is a concern in some schools across Europe). Stop-motion also helps to understand how all videos and moving images are produced. They are a sequence of still images. A "moving" image does not actually exist; it is created in our brains. When we see roughly 25 still images per second, our brains transform them into a moving image.	As long as a concept is directly related to a real life situation, we are able to capture it in a one-shot video. Unfortunately, most mathematical concepts are abstract. They exist only in our minds and have an indirect relation to the real world. Fortunately, stop-motion is a powerful way to visualise abstract ideas. We tried vidumath with many different abstract mathematical concepts: the equal sign (equations), symmetry (both mirror and rotational symmetry), the commutative property of addition and multiplication, proportionality, the sum of angles (in a triangle), equivalent fractions, measurement of area, and there are many more. While the students plan and produce their video, the teacher can observe not only how much the children already know about the new topic, but as well what kind of misconceptions they have. A misconception is a conclusion that's wrong because it's based on faulty thinking or facts that are wrong. Misconceptions are normal for someone who yet doesn't know all the facts. To become aware of one's own misconceptions is a necessary step in the learning process. This happens sometimes already while planning or filming the video, but for sure when reflecting on the videos. Here are some misconceptions and mistakes that we have observed during the try-outs: ♦ The equal sign means: "Act out the left hand side and write the result on the right hand side!" (Typical answers to the equation 8 + 4 = □ + 5 are 12 or 17.) ♦ An equation is something that can only be solved by applying the correct algorithm. It is not related to reality. ♦ The unit of a fraction is not divided into equal-sized shares. ♦ Decisions about equivalence and order of fractions are made when fractions refer to different units or similar units that are not the same size.	For a problem it is essential that the students don't have any memorised or prescribed methods how to solve. However, there are a lot of general strategies that can be applied when we have to solve a problem. Powerful strategies both to understand the problem and to explain the solution are ♦ Visualise the problem or a relevant process or situation ♦ Draw a picture or diagram of the problem or a relevant process or situation ♦ Create a model of the problem or a relevant process ♦ Imagine being the problem, a key process, or the solution ♦ Simulate or act out a key element of the problem ♦ Consider a specific example vidumath enables students to do this in a creative way. The following problem can be solved by trial and error, but to really understand the solution, a stop-motion visualisation is very helpful. We tried the following problem with a 13 year old boy: *https://youtu.be/7pN3zZljB9k* You have a pancake. You want to cut it by knife cuts in as many pieces as possible. The pieces don't need to have the same size. What is the maximum number of pieces that a pancake can be cut into by four straight cuts? 	Instead of just restating the important ideas, **synthesising** involves combining ideas and allowing an evolving understanding of the mathematical concepts. It means to put pieces together to see them in a new way. It is crucial for conceptual understanding that students make connections between apparently separate mathematical ideas. For example, fractions, decimals, percentages, and proportions are sometimes taught as separate topics, but in fact they are only different representations of the same fundamental mathematical idea. Synthesising requires students to process and interact with the ideas rather than simply copying and pasting information. Students are actively engaged with the material when they categorise, analyse, combine, extract details, re-assess the value of the learned concepts and procedures, look for bias, omissions, etc. All of this happens when they plan a video about the content they have learned. Finally, they relate their new understanding to their prior knowledge and experiences and develop new meaning. This higher-order thinking skill is challenging for children and needs explicit scaffolding by the teacher. Tasks that help students to learn synthesising their mathematical ideas are: ♦ Use different representations to solve a mathematical task and show how they are related to each other, e.g. illustrate the solution for 103 – 28 using an empty number line, a base-ten model, and a notational representation. ♦ Show how the new mathematical concept is related to other mathematical concepts, e.g. show how multiplication is related to area, grouping, addition, and counting. ♦ Show how the new mathematical concept is related to everyday life, e.g. show an example how knowledge about fractions helps you to solve a real life problem. Students can for example animate dolls.
Advanced task **Creative explorations** ♦ **Production:** This is open for different video production ideas but is based on "proper" video production including camera work and video editing ♦ **Possible mathematics content:** All mathematics content can be included here: documentation of mathematics classes / events; any classroom content; music and drama mathematics displays; … The advanced task is advisable only once entry or intermediate tasks have been completed and the students possess an adequate knowledge of video production. It is totally open to any form of video production and any kind of mathematics tasks.	If the students already know how to produce advanced videos, this can be used to introduce any topic you want. It is very suitable for discovery tasks like finding everyday situations related to the mathematical operation or object you want to introduce. As an example, we produced a video about shapes and numbers in the German city Potsdam: *https://youtu.be/ dYrnP6pf-Q* 	Any kind of problem can be chosen here. There are lots of different heuristic strategies how to solve problems and the possibilities to visualise both the solving process and the solutions and even more. We tried the following problem with prospective teachers at the University of Ljubljana, but it would be suitable for primary and secondary school, too: You have 8 places in a row. 8 persons shall be placed in that row. But the problem is: People with the same colour don't like each other. There has to be • 1 place between the yellow people, • 2 places between the green people, • 3 places between the blue people, and • 4 places between the red people. 	If students shall consolidate or show their knowledge about a mathematical concept that is closely related to real life problems, it is better to visualise it with real people acting and not just stop-motion animation. An example of this was produced during our try-outs by students from a hotel and tourism vocational school in Coimbra. The students were asked to show their knowledge about proportionality as it is needed for preparing meals in a hotel or restaurant. They choose to explain how a chef can scale a recipe that is designed for ten people to a group of twenty two people: *https://youtu.be/GtvRq7Mm-fA*