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tablets in education

Meaningful learning using mobile devices (short version English)

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TABLIO-project
Tablets for classroom differentiation and inclusion
Erasmus+ Key Action 2: Cooperation for innovation

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PROJECTPARTNERS

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1.   Context and motivation

1.1   The schools

The design team included two teachers from different primary schools in Nijmegen, the Netherlands: *De Driemaster* and *Het Kleurrijk*. Both schools are part of the school board *St Josephscholen*.

1.2   The motivation

Both schools have been working with mobile devices for some time (Chromebooks in the upper years, tablets in the lower years). These are mainly used as a class or for working individually with drill and practice software. The teachers also see opportunities to use the devices to contribute to more meaningful education.

1.3   The design team

The team consists of:
- Koen Jansen, teacher year 8 (11-year-olds) at *De Driemaster* primary school
- Meral Bekdemir, teacher year 3/4 (6/7-year-olds) in the 2017/2018 school and year 5/6 (8/9-year-olds) in the 2018/2019 school year at *Het Kleurrijk* primary school
- Jacqueline Goedhart, process manager from iXperium/CoE
- Marjoke Bakker, researcher at iXperium/CoE
- Roland Kok, teacher educator primary education at HAN University of Applied Sciences
- Barbara Berends, ICT coach at iXperium/CoE
- Pieter van Rooij, ICT expert at St Joseph Schools and specialist in learning and teaching with ICT at iXperium, was affiliated with the team as an interested party until November 2018

1.4   Design question and objectives

The teachers developed their goals further by using the *Innovatieversneller* (Innovation Accelerator) toolkit from Kennisnet (2015). Both teachersmentioned the use of mobile devices at school as an opportunity. The devices were already being used, but the teachers thought they could be used in different and more meaningful ways. At present, ICT is mainly used as a class or for working individually with drill and practice software. The teachers see the availability of the mobile devices as an opportunity to enrich education and deepen learning: the devices could contribute to more meaningful learning. They could also be used to offer a broader range of learning activities (to enhance pupils' motivation) and to better accommodate differences between students (differentiation; e.g., in terms of level or instructional method).
The teachers want to include their teams in the more meaningful use of the devices. They also want their colleagues to learn how to design meaningful learning activities/learning arrangements and thus approach education differently: not just by

following the textbook series, but by occasionally replacing part of the textbook series with a more meaningful learning activity.

At *Het Kleurrijk*, disappointing mathematics test results have led to a focus on improving mathematics education. The teachers think that applied mathematics (mathematics in practice/context) could help in this process. There is also a lack of intrinsic motivation and independence among the pupils. Their attitude when working on assigned tasks is poor. The teachers believe the pupils' problems with motivation and work attitude are one cause of the poor mathematics results. Pupils also have a poor work attitude/motivation in relation to other subjects.

Our design question is:

How can I (re)design meaningful learning activities/learning arrangements in which pupils use mobile devices in a meaningful way?

In summary, we want to achieve the following objectives with our design:

1. We want to use meaningful learning arrangements with ICT to ensure that pupils are more involved in the subject, that they understand more clearly why they are learning something and that the learning outcomes improve.
2. We want to encourage other teachers at school to design and implement meaningful learning arrangements with ICT for their pupils.

A potential product would be a set of developed meaningful learning arrangements with ICT that include various ICT applications. These learning arrangements would serve as examples and inspiration for the school team to use mobile devices in different, more meaningful ways.

Our working hypothesis is:

By using meaningful learning arrangements that include mobile devices (Chromebooks/iPads) and that involve differentiation

I expect that for various school subjects

Taught to primary school pupils (especially the upper year)

I will achieve
For pupils:
- more engagement with the subject matter
- improved learning outcomes

For teachers:
- more meaningful use of mobile devices by the school team

Because meaningful learning arrangements are expected to ensure greater engagement in learning and could improve pupils' understanding of why they should learn something. We expect this to lead to greater motivation and more intensive learning. Pupils will be approached differently, which will make it easier for some pupils to master the material. Differentiation is arranged by providing students with choice in, for example, the way in which they do the assignments. In this way pupils' individual learning needs are accounted for. This is expected to contribute to greater engagement and improved learning outcomes.

And I see this reflected in improved engagement and more intensive commitment of the pupils. Pupils learn implicitly: they are implicitly involved with acquiring or practicing knowledge or skills because they are needed for the assignment, not 'because they must'.

1.5   Method and timeline

The methodology of iXperium design teams involves five phases:
- Clarifying the question
- Exploring and collecting information
- Establishing design requirements
- Designing, experimenting and testing
- Evaluating and sharing

These phases are not usually explicitly sequential; they often overlap.
In this design team, the teachers started designing and implementing meaningful learning arrangements in their classes very early on in the design team process. This already started while the team was still exploring and collecting information and drafting design requirements. Discussing and evaluating these initial designs significantly contributed to clarifying the definition of meaningful learning arrangements, how ICT can be used in them, and how they can accommodate differences between pupils (exploring and collecting), and which characteristics these learning arrangements must have (establishing design requirements).
The timeline in Figure 1 shows how the design team's process unfolded. In total, eight sessions (blue) were held over one year. Between sessions, teachers were involved in

designing, redesigning, implementing and evaluating learning arrangements (orange). The teachers were supported by worksheets/homework assignments.
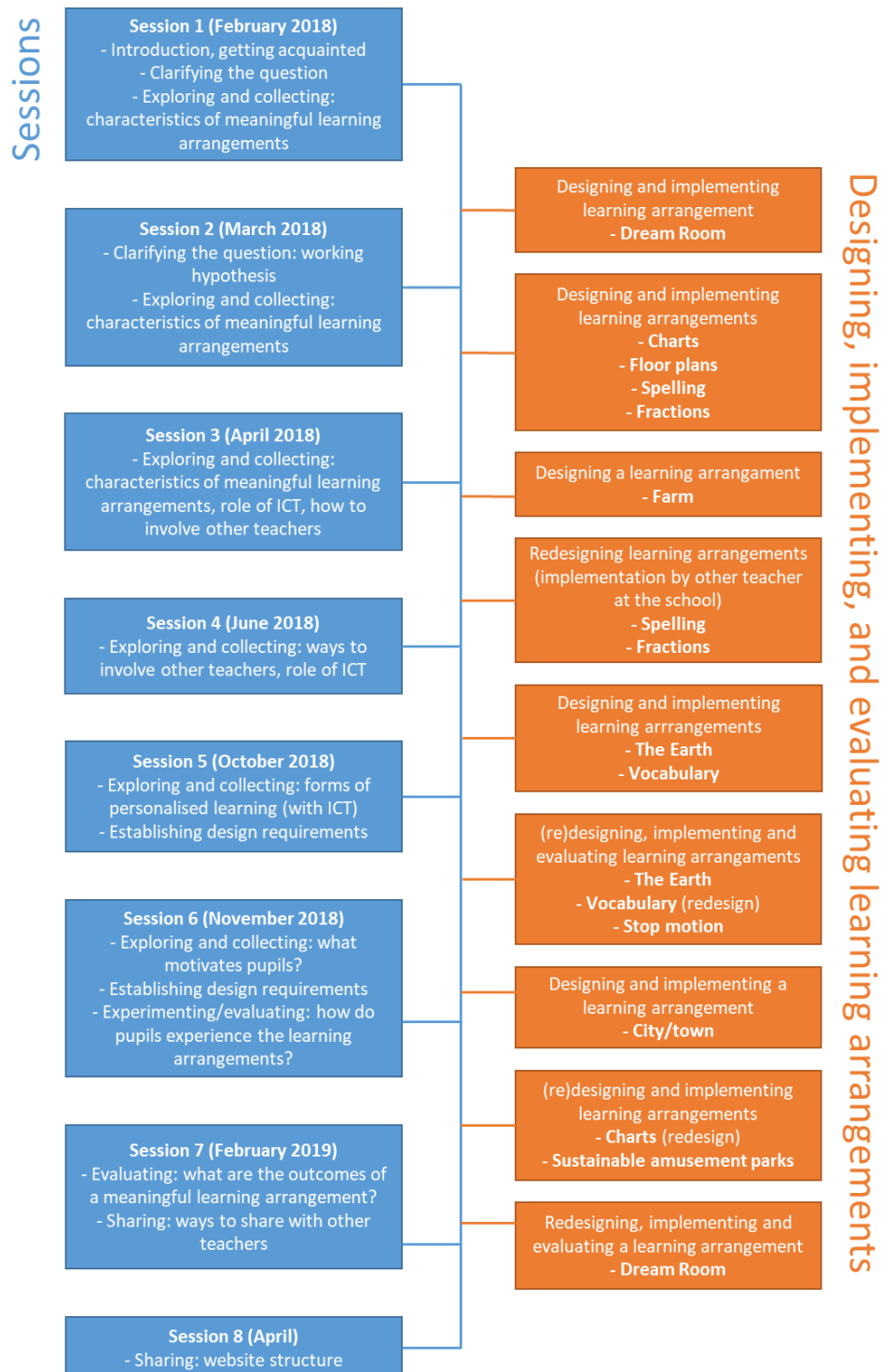

Figure 1. Timeline of the design team process.

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2. Exploring and collecting

During the explore and collect phase, the most important concepts from the design question were elaborated upon: meaningful learning, the use of ICT in this context, and differentiation. In parallel, the teachers designed and tried out various small-scale learning arrangements in their classes, exploring meaningful learning using ICT and aspects of differentiation.

2.1 What are meaningful learning arrangements?

We took various steps to arrive at a consensus on the definition of meaningful learning arrangements. In the first session, we discussed what teachers mean by 'meaningful learning situations using mobile devices' and explored some examples.

The teachers appeared to differ in their definitions of meaningful learning. Aspects discussed included: having pupils formulate their own learning objectives or learning questions, projects in which pupils get creative with a theme and make something themselves (e.g. design a house, make a poster, compile a quiz), connecting to pupils' interests, and linking the learning content to a context or to daily life to clarify why it is important to learn it. Autonomy plays an important role: pupils decide autonomously in what way they want to work on the learning content, or which learning questions they want to work on. Mobile devices can be used in meaningful learning to 'bring the world into the classroom', to look up information, and to create things (e.g. videos, designs). One of the teachers said the following about meaningful learning and the role of devices in this process:

'To me, meaningful means that children know and understand why they are doing something. This involves making connections with other subject areas and stimulating the pupils' curiosity. Mobile devices make it possible to bring the world into the classroom. All information is available; children can actually see the North Pole when they are studying the North Pole. Devices provide the teacher with many different options and tools to quickly switch between subject areas, to have children ask their learning questions and to have them search/work in the way they prefer.'

To prepare for the second design team session, the teachers described several examples of meaningful learning activities with ICT in their schools. This gave them a clearer picture of important characteristics of meaningful learning arrangements and the corresponding role of ICT. In addition, the teachers brainstormed about new ideas for meaningful learning activities with ICT. They further developed one of their ideas and implemented it in their own class. During the session, we discussed what made these learning activities meaningful to us. Below are some of the learning activities/arrangements discussed and their meaningful characteristics:

- Using Padlet (https://en.padlet.com/) to activate prior knowledge and having pupils formulate their own (learning) questions about a theme. Then, pupils look for information about the theme and put it on the Padlet wall. Meaningful aspects: activating prior knowledge, formulating their own learning question.
- Having pupils make a stop motion video for mathematics to explain a self-selected learning goal. Pupils were very engaged and chose a method that fit their preferences. Meaningful aspects: creating, working on their own learning goal, explaining, working in their own way.

- Having pupils learn to ask questions about a text by creating a quiz for other pupils in Kahoot (https://kahoot.com). This activity is especially meaningful because pupils make the quiz for someone else and they actually use it. A quiz in Kahoot also has a competition element (gamification), which has a motivating effect.
- Having preschool children search the school for objects that start with a certain letter. They take photos and create a poster in PicCollage (https://pic-collage.com/). Meaningful aspects: deliberately searching in a physical environment, being creative, making a poster the way you want it.
- Dream Room learning arrangement: Pupils had to design their dream bedrooms. First, they made a sketch, then they elaborated on it in Floorplanner (https://floorplanner.com/). Finally, they made a physical scale model from cardboard. The pupils were very motivated. The scale calculations have an intrinsic purpose in the activity (i.e. to be able to make the dream room), so pupils learn to work with scale in practice. Other meaningful elements: making something, deciding for yourself how to make it, active learning.
- Practising multiplication tables with Gynzy Kids (drill and practice software with game elements). Pupils were enthusiastic and enjoyed the activity. They playfully practised the multiplication tables. It is a motivating learning activity, but we do not find it very meaningful, because practising the tables does not occur in a meaningful context (calculating multiplication problems has no intrinsic purpose in Gynzy Kids).

Based on the discussion of these examples of learning activities/arrangements, we prepared a list of possible characteristics of meaningful learning arrangements:

- Pupils understand why they do or learn something and reflect on this (give it meaning)
- Connecting with practice/living environment/context
- Creating
- Pupils are co-owners
- Based on the pupils' interests
- Activating prior knowledge
- Making something that is actually used (e.g. by pupils from another class)
- Explaining by pupils
- Working at your own level
- Choice (e.g. of interests, topics, way of learning)
- Collaboration
- Competition
- The learning has importance/use for the pupils
- Deliberate engagement with the learning content
- Concrete applications

The pupils' motivation is often reflected in the examples discussed. We do not see this as a characteristic of a meaningful learning arrangement, but rather as a possible consequence of working with such arrangements. Motivation can also be achieved through variation in learning activities, for example. 'Enjoyable' vs. 'meaningful': an enjoyable or motivating learning arrangement is not necessarily meaningful; a meaningful learning arrangement is not necessarily enjoyable or motivating.

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To prepare for the third design team session, we examined our list of possible characteristics of meaningful learning arrangements based on literature (including Van Slobbe & Van Ast, 2015; Howland, Jonassen, & Marra, 2012) and our own practical experience. The two teachers collected arguments for all possible characteristics relating to why they are, or are not, an essential characteristic of meaningful learning arrangements. We then discussed this in the session. We finally arrived at three essential characteristics of meaningful learning arrangements:

- Context / authentic / imaginable / corresponding with daily experience or practice
- Active learning / creating / making something
- Autonomy/choice regarding the approach (differentiation in how pupils learn)

Features we do not think of as essential but would be nice to have:

- Differentiation according to level (related to autonomy)
  - Differentiation in difficulty of the activity
  - Differentiation in degree of guidance
- Activating prior knowledge (helps to put the activity in context)

The characteristics of differentiation can be found in the Tablio concept map on differentiation (see Figure 2). Our case concerns differentiation at the micro-level. Autonomy and choice regarding the approach are about differentiation focused on the pupils' learning profiles and interests. Differentiation according to level can be found in the concept map as differentiation aimed at students' readiness. According to the abovementioned characteristics, meaningful learning arrangements may involve content differentiation (e.g. when pupils can choose fields of interest, learning questions or difficulty levels), process differentiation (choosing the approach and differentiation in degree of guidance), and/or product differentiation (when pupils can choose how they develop the product).
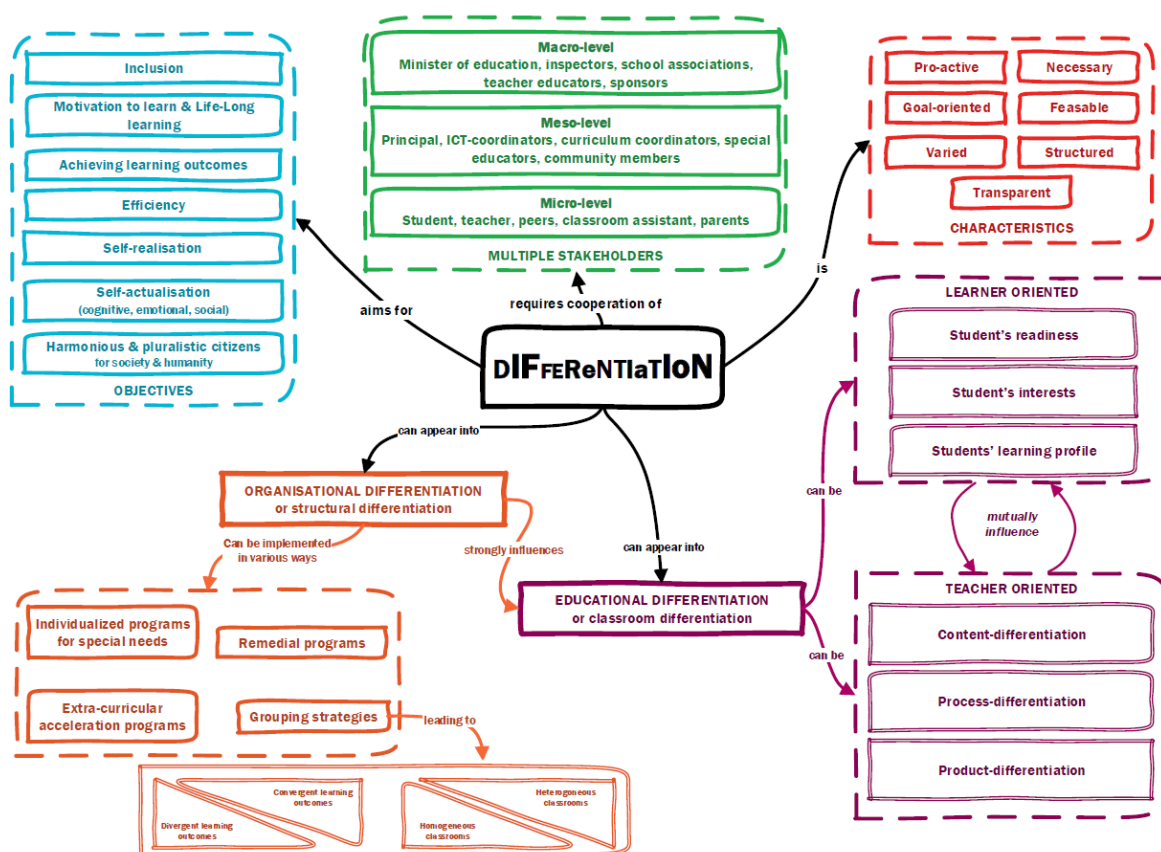
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Figure 2. Tablio concept map on differentiation (tablio.eu).

In the fourth design team session, we asked whether 'meaningful' should always apply to the learning content or whether it could also be a meaningful (motivating) learning activity that is not necessarily related to the subject. We are in favour of the first option. As an example, we discussed a learning activity in which pupils have to move a Beebot to a fraction or decimal number that corresponds with a certain percentage. It is an enjoyable exercise, but we do not find it truly meaningful (according to our definition) because steering the Beebot (e.g. left, right, forward) has nothing to do with fractions or decimal numbers. However, if working with the Beebot resulted in a discussion about fractions, this could be meaningful. Having pupils create their own mat for the Beebot would also be more meaningful, because then it would be more about the content. Motivational exercises without substantive meaning can also be very useful, but the design team focused on substantively meaningful learning arrangements. Another learning activity we discussed is having pupils make a presentation on a topic (e.g. World War II) using their own choice of presentation format (e.g. a green screen, Book Creator, Prowise Presenter, nieuwstool.nl, or iMovie). Pupils would have their own responsibility to present the topic and include the learning contents in the presentation. Presenting with ICT allows for more motivation and self-directed learning: pupils will try to find out by themselves how things work. With such motivating learning activities, a balance must be found between motivation related to the medium (e.g. an enjoyable learning activity with a green screen) and motivation to achieve substantive learning objectives. Motivation can be seen as a means to more easily achieve the learning objective.

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> **What should we take from this for our design?**
>
> The meaningful learning arrangements to be designed must have these characteristics:
> - Context / authentic / imaginable / corresponding with daily experience or practice
> - Active learning / creating / making something
> - Autonomy/choice regarding the approach (differentiation in how pupils learn)
>
> Additional nice-to-have features are:
> - Differentiation according to level (related to autonomy)
>   - Differentiation in difficulty of the activity
>   - Differentiation in degree of guidance
> - Activating prior knowledge (helps to put the activity in context)

2.2   Use of ICT

The SAMR model from Puentedura (2009) distinguishes four levels of the use of ICT in a learning activity. These range from Substitution (ICT as a replacement for a traditional learning material, e.g. book behind glass) to Redefinition (redefining education in a way that would be impossible without ICT) (see Figure 3).
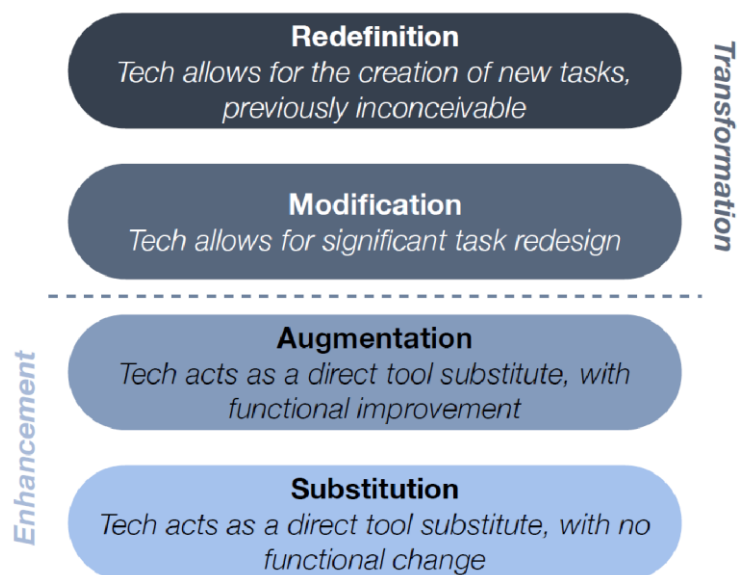
Figure 3. The SAMR model, taken from Puentedura (2009).

We use this model to evaluate and improve the use of ICT in meaningful learning arrangements. In Session 3, we evaluated some of the meaningful learning arrangements designed by the team, using these questions with respect to the SAMR-model:
- What is the current level of ICT in the learning arrangement?
- What can we change to reach a higher level of ICT use? And is this desirable in view of the learning objectives of the learning arrangement?

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Based on the discussion of the learning arrangements using the SAMR model, we concluded that we aim for meaningful learning arrangements in which the ICT has an added value. This does not necessarily mean that a higher level in the SAMR is better. We want to create meaningful learning arrangements in which ICT makes an important contribution; we should not use ICT for the sake of using ICT.

What should we take from this for our design?

- ICT use must provide added value in the meaningful learning arrangements to be designed. We aim for ICT use at at least the Augmentation level in the SAMR model.
- During the design process, the SAMR model can be used to evaluate whether the use of ICT in the learning arrangement can be improved.
- The level of ICT use from the SAMR model that is most suitable for a learning arrangement may differ depending on the learning content and learning objectives.

2.3   Differentiation and personalised learning

Both teachers on the design team expressed ambition to move towards more personalised learning. The learning arrangements to be designed should contribute to the teachers' ambitions and must therefore contain elements of personalised learning. To evaluate the extent to which the designed learning arrangements contain elements of personalised learning, the *Meetlat Rechtdoen aan verschillen* (hereinafter the Personalised Learning Scale) from iXperium/CoE can be used. This scale consists of several evaluation questions to assess the extent to which various aspects of personalised learning are used in a learning arrangement and what the role of ICT is in this context (see boxes below).

In Session 5, we used this scale to evaluate one of the learning arrangements designed by the team. We went through all the questions from the scale and discussed the following for each question:
- whether and to what extent the aspect of personalised learning is included in the learning arrangement
- how this aspect – possibly using ICT – could be included (more) in the learning arrangement and whether this is desirable considering the learning objectives.

In this way, the Personalised Learning Scale can be used to evaluate the extent to which a designed learning arrangement accommodates differences between pupils and to identify possibilities for improvement in this regard.

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Evaluation questions from the Personalised Learning Scale (*Meetlat rechtdoen aan verschillen*) from iXperium/CoE

Dimension: standardisation versus differentiation
- *Is there differentiation according to **what** is learned?*
- *Is there differentiation according to **difficulty level**?*
- *Is there differentiation in **where and when** learning takes place?*
- *Is there differentiation in **how** the pupils learn?*
- *Is there differentiation in the **pace/duration** of the learning process?*
- *Is there differentiation in **instruction**?*
- *Is there differentiation in the **way of processing** the learning material?*
- *Is there differentiation in **evaluation/feedback** on learning?*
- *Is there differentiation according to pupils' **interests**?*

Dimension: external direction (by teacher or tool) versus self-direction by the pupil
- *Can pupils decide **what** to learn?*
- *Can pupils decide **when** to learn?*
- *Can pupils decide **who** to learn with?*
- *Can pupils decide **where** to learn?*
- *Can pupils decide **at what pace** to learn?*

What should we take from this for our design?

- We aim to create learning arrangements that accommodate differences between pupils in various ways.
- During the design process, the questions from the Personalised Learning Scale can be used to evaluate whether the learning arrangement can be improved in terms of differentiation or personalised learning.

2.4   Encouraging fellow teachers

One of the design team's goals is to include the school team in the developments: we want our fellow teachers to implement and design their own meaningful learning arrangements. This leads to the following question: how can fellow teachers be encouraged to design and implement meaningful learning arrangements that use ICT? This probably requires a change in attitude, such as less strictly following the textbook series or feeling free to do something in a different way. Regarding the school organisation, this requires an environment in which teachers are given the freedom and time to experiment.

The teachers from the design team reported that their fellow teachers like to be offered something to start with, before they begin working on new ideas themselves. They also reported that teachers become motivated when they see that pupils are motivated. One way to motivate teachers could be by first showing them how pupils respond to meaningful learning arrangements (e.g. by having teachers try one in their classroom or by showing them a video).

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In our design team, we want to design a set of meaningful learning arrangements with ICT that can serve as inspiration for fellow teachers. They can try out these meaningful learning arrangements in their own classrooms and experience the effects they have on their pupils. This will hopefully encourage them to work more with meaningful learning arrangements (possibly self-designed) in their teaching. Videos or photos of the learning arrangements can give teachers an impression of the learning arrangements and the reactions of pupils before they try the arrangements themselves. To better involve fellow teachers in designing meaningful learning arrangements, the teachers on the design team designed some learning arrangements together with a fellow teacher, for the fellow teacher's class. To this end, they brainstormed together with the fellow teacher about learning objectives and meaningful learning activities, and then co-designed a learning arrangement around the chosen learning objective, which the fellow teacher then implemented in the classroom.

2.5   What motivates pupils to learn something?

To better understand what motivates pupils to learn something or when learning is really meaningful to them, in preparation for Session 6, the teachers asked their pupils to describe situations in which they really wanted to learn (i.e., because they wanted to know about something or know how to do something). These could be situations at school or outside of school, such as at home or as part of a hobby.

In year 8 at *De Driemaster*, many pupils described learning moments related to sports. Learning moments at school were also mentioned. Pupils often want to learn something because it is cool to do it, like a trick in sports. They want to impress. Pupils also want to learn things because other people can do these things. Furthermore, pupils mentioned things related to their interests. One pupil wanted to learn something new in a game to advance to a higher level in that game.

In year 5/6 at *Het Kleurrijk*, many pupils also mentioned something they wanted to learn in sports, such as tackling. In addition, several school subject areas were mentioned, such as mathematics and history. Some pupils gave unusual answers: for example, one pupil wanted to learn how to catch mice because his home was infested with mice. He wanted to learn out of necessity. Pupils also mentioned wanting to learn how to work with technology, for example the Chromebook.

From the above, we conclude that it is meaningful for the pupils to learn something because they need it, because it is fun to be able to do it, because they want to impress, or because they do not want to lag behind other children.

3. Design requirements

The intended product of this design team is a set of meaningful learning arrangements with ICT. These learning arrangements should serve as an example and inspiration for the school team to use mobile devices in different, more meaningful ways. The learning arrangements accommodate differences between pupils (differentiation/personalised learning)

Based on the design team's goal and the exploration of theory and practice, several design requirements have been drawn up. These not only include design requirements for the single learning arrangements that we design, but also design requirements for the entire **set** of meaningful learning arrangements. In addition to design requirements, we also have some design wishes (not essential, but nice to have).

3.1   Design requirements and wishes

Target group
- Requirement: The learning arrangements are intended for primary school pupils (especially the upper years, since the teachers on the design team teach those years).
- Requirement: The set of learning arrangements is aimed at primary school teachers: they must be able to implement these learning arrangements and be inspired to devise similar learning arrangements themselves.
- Wish: The set of learning arrangements is varied with regard to the target group: the learning arrangements are aimed at pupils in different school years, possibly the lower years as well. Reason: variation in learning arrangements increases the likelihood that other teachers will start using an arrangement and be inspired to design learning arrangements themselves.

Subject
- Requirement: There is a focus on mathematics at *Het Kleurrijk*, so there must be at least one learning arrangement from this school that focuses on mathematics.
- Wish: In the set of learning arrangements, different learning arrangements focus on different subjects. Reason: variation in learning arrangements increases the likelihood that other teachers will start using an arrangement and design learning arrangements themselves.

Learning objectives, alignment with curriculum/textbook series
- Requirement: The learning arrangements are in line with learning objectives from the curriculum/ textbook series. The approach in practice may deviate from the textbook series; this is even encouraged!

Characteristics of the learning arrangement
- Requirement: The learning arrangements to be developed are meaningful. They must have the following characteristics (based on the established definition of meaningful learning arrangements):
  - Context / authentic / imaginable / corresponding with daily experience or practice
  - Active learning / creating / making something

- Wish: Activate prior knowledge (this helps place the activity in a context). Reason: based on established definition of meaningful learning arrangements.
- Wish: Pupils create something in the learning arrangement that is actually used (e.g. by others) or is presented to others. Reason: this increases meaningfulness (shown by experience in practice).

Form of differentiation
- Requirement: Autonomy/choice regarding the approach (based on the established definition of meaningful learning arrangements). For example, choice in the amount of detail, how information is gathered, software used. Choice is not necessary for everything; some aspects may also be predetermined (e.g. the software used).
- Wish: Differentiation on various aspects if possible. During the design process, the learning arrangement can be evaluated using the Personalised Learning Scale: does the learning arrangement involve differentiation on the aspects mentioned? (Is this aspect the same for all pupils or are differences between pupils considered?) Can (more) differentiation on this aspect be integrated into the learning arrangement and is this desirable?
- Wish: If possible, include various forms of self-direction. During the design process, the learning arrangement can be evaluated according to the aspects of self-direction from the Personalised Learning Scale: Is this aspect of self-direction included in the learning arrangement? Can this aspect be added and is it desirable for this learning arrangement?

Grouping forms
- Wish: Collaborative learning. Various grouping forms are possible, such as heterogeneous groups for learning from each other. There should also be room for pupils to work individually. Reason: based on evaluating meaningful learning arrangements in the classroom and the meaningful learning pentagon (Howland et al., 2012).

Role of ICT
- Requirement: ICT must add value to the learning arrangement. At a minimum, it must provide Augmentation according to the SAMR model (more than a book behind glass). The SAMR model can be used to explore whether ICT can be used at a higher level. The optimum level in the SAMR model must be determined based on the learning objective of the learning arrangement.

Hardware
- Requirement: Chromebooks or tablets are used in the learning arrangements. Reason: based on the aim of the design team and the school practice.
- Wish: the set of learning arrangements preferably includes arrangements using a Chromebook (upper years) and arrangements using a tablet (lower years). Reason: more variation means greater likelihood of use and design by other teachers, because they see various possibilities and this improves the chance that they will find something that suits their educational practice.

Software
- Requirement: The software is easy to use or learn to use by pupils and teachers
- Wish: Various software packages are used in the learning arrangements within the set. Reason: variation in learning arrangements increases the likelihood

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that other teachers will start using an arrangement and design learning arrangements themselves.

Organisational aspects (duration, planning, preparation time)
- Wish: The learning arrangements do not require too much time; this keeps them accessible for use by other teachers. However, a meaningful learning arrangement often requires several lessons.
- Wish: The learning arrangements replace regular lessons on the corresponding learning content/learning objective. Sometimes extra time is required, such as time normally reserved for crafts, ICT, or projects, or it can be part of the weekly task.
- Wish: The designed learning arrangements should require little preparation time for teachers to use them in the classroom. The required preparation time partly depends on the teacher's familiarity with the software used.

The teacher's role
- Wish: The teacher primarily takes a supportive or coaching role, but instruction can also be part of the learning arrangement

Accessibility/low threshold to use by the teacher
- Requirement: The learning arrangements and software must be easy to use, so teachers are not deterred from using them.
- Requirement: The learning arrangements contain a clear description/manual, so other teachers can implement them without further assistance.
- Wish: The description/manual of the learning arrangements includes photos or videos where possible, so other teachers get a good picture of the learning arrangement and preferably of the positive reactions of pupils. This can encourage other teachers to implement or design meaningful learning arrangements themselves.
- Wish: The learning arrangements can be implemented by other teachers without the need for specialist knowledge or skills related to the ICT resources used.

Assessment of learning outcomes
Learning outcomes of meaningful learning arrangements can be assessed by, for instance, asking pupils to explain what they learned. Suitable forms include presentations, portfolios, or demonstrations of the products the pupils created. Regular assessments can also be used, since the learning arrangements are developed to be in line with the learning objectives from the curriculum.

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4.   Designing, experimenting and testing

4.1   Designing and testing learning arrangements

During their involvement in the design team, the teachers designed and tested various meaningful learning arrangements in their classes. As described in Section 1.5, this designing and testing took place partly in parallel with the phases of exploring, collecting and establishing the design requirements. This means that some of the tried-and-tested learning arrangements do not meet all design requirements (see the time line in Section 1.5).

Below is an example of one learning arrangement. The teacher's experiences in the classroom practice are also reported.
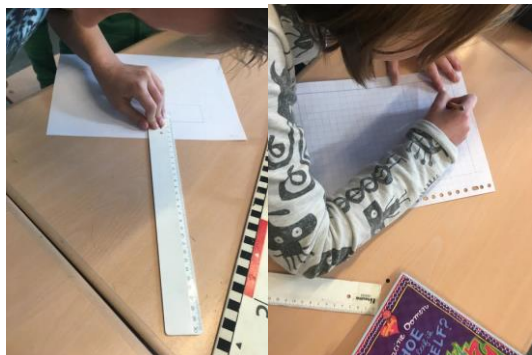

Dream Room learning arrangement (first design)

Koen, year 8 teacher, De Driemaster

**Description of the learning arrangement**
The aim was to do scale calculations.
Children started to think about their dream rooms, and first made a rough sketch on paper.


The rooms really came to life when the children worked out their sketches using Floorplanner.com. The interiors took shape, the walls were coloured, and they saw the extent to which their sketches were realistic: the walls and floor area were adjusted to the agreed dimensions (4 x 6 metres).
Children saw their drawing in 2D, but they could also use the 3D function to enter their room.
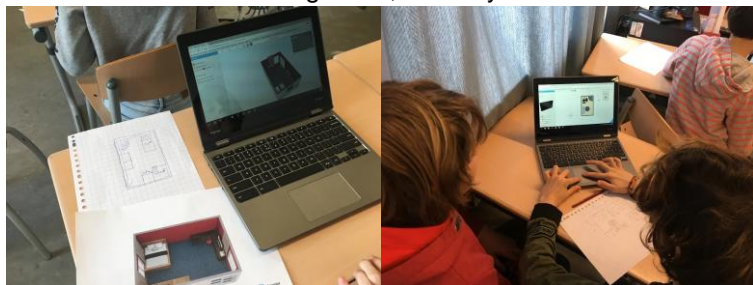
When a room was ready, I printed it in 2D and 3D and the children used this printed image to determine the correct dimensions of everything in the room. This was essential because the next step was to make a physical model (crafts). We agreed on a scale (1:20) and the children started to make their scale model according to their designs.

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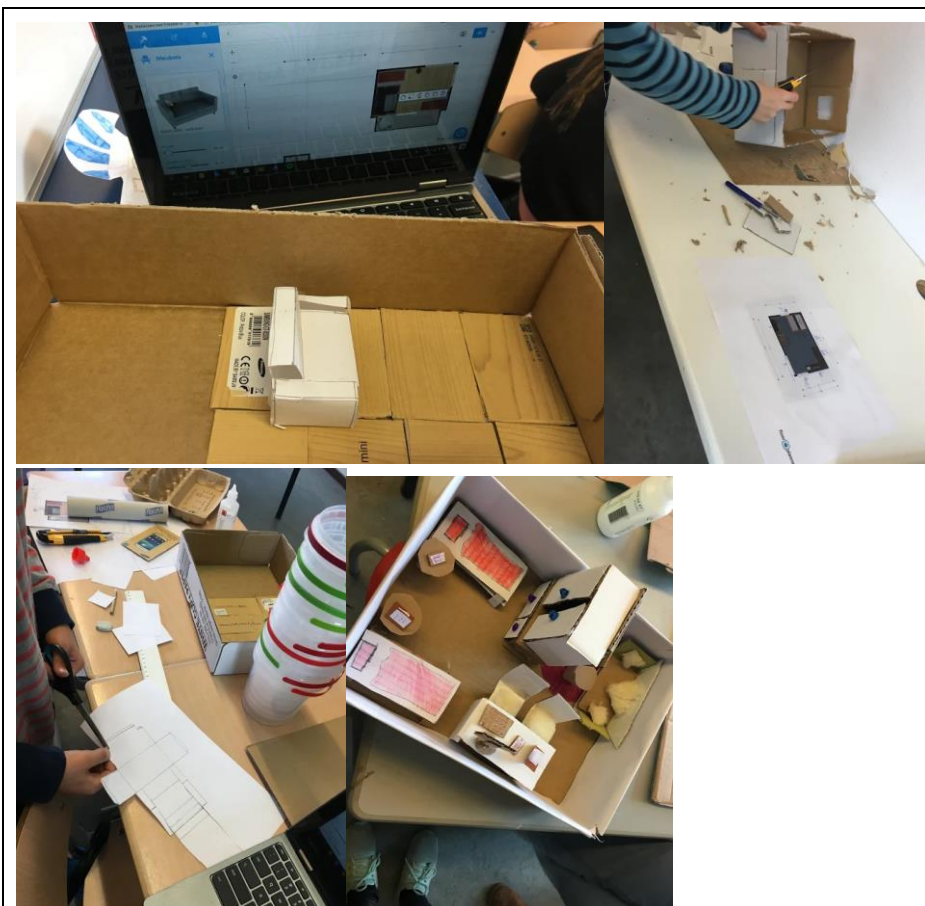
How did the teacher experience this learning arrangement in the classroom?
As very positive and pleasant. Children were actively involved in all phases of the assignment. It was about scaling, and I made that clear to the children often by repeatedly asking if their initial sketch was correct or by having them think about how big something should be.

The ICT part was used to bring their dream rooms to life. The children enjoyed designing the rooms, and it was up to me to check that the process was not just about having fun, but also to make sure they were really thinking about the dimensions: what would fit and what were the possibilities?

What did the pupils learn (according to the teacher)?
It is difficult to say whether this was a better way for the children to learn than just using regular books. What I saw was that the children were enormously engaged, and they really thought about all the learning questions. The children were not just doing sums but were deliberately working on the scale calculations. We also had a good class discussion about what the scale should be and what that means.

What were the pupils' reactions?
The children were very positive. They did not fully realize that it was actually a mathematics lesson, and they wished that mathematics lessons would 'always' be like this.

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4.2   Redesigning learning arrangements

In the design team process, the teachers redesigned several of the tried-and-tested learning arrangements. They did this based on their findings during the trials and based on the information collected during the exploring and collecting and establishing design requirements phases (see timeline in Section 1.5). They used the established characteristics of meaningful learning arrangements (see Section 2.1), the SAMR model (see Section 2.2) and the personalised learning scale (see Section 2.3) in the redesign process. The redesign of the Dream Room learning arrangement is described below.

Redesign of the Dream Room learning arrangement
Koen, year 8 teacher, De Driemaster
Description of redesigned learning arrangement
Learning objectives:
Pupils can calculate with ratios and a given scale.

Lesson description:
The pupils will design their dream rooms. They work in pairs.
- First, they make a sketch of their design. Based on some given requirements (dimensions of the room, scale 1:20), they sketch their room on paper. They determine the dimensions of furniture, for which they can use a calculation tool in Google spreadsheets. Then they go to a website (made for this purpose by the teacher) to choose paint and flooring. In addition, they must calculate how much paint and flooring is needed and how much it costs, while remaining within a certain budget.
- The pupils then work out the design using the website www.floorplanner.com. This shows them whether their estimates of the furniture dimensions are correct. They can 'stand' in their room in 3D, and the room can be printed.
- As a final step, the pupils craft a scale model of the room in which the furniture must be made to scale.

Differentiation/personalised learning:
- The pupils are assigned to pairs based on their level in mathematics: either two pupils with high level in mathematics who can challenge each other, or two pupils of different levels who can help each other.
- The instruction and explanation about calculating scale is given in an instructional video on www.edpuzzle.nl. The instructional video also includes questions/assignments about calculating scale; the teacher can immediately see the answers that the pupils enter and provide them with feedback.
- The instructions can be viewed and reviewed by the pupils at their own pace using the instruction video or a text document in Google Docs.
- There are two variants of the learning arrangement: the regular variant and the challenging variant. In the challenging variant, pupils can choose the scale they use and the calculation tool is not available. The available budget is also smaller in this variant.

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5. Evaluating and sharing

The design team had two main objectives (see Section 1.4):

1. We want to use meaningful learning arrangements with ICT to ensure that pupils are more involved in the subject, that they understand more clearly why they are learning something and that the learning outcomes improve.

2. We want to encourage other teachers at school to design and implement meaningful learning arrangements with ICT for their pupils.

To achieve these objectives, the design team's goal was to develop a set of meaningful learning arrangements with ICT that accommodate differences between pupils. These learning arrangements can then serve as examples and inspiration for the school team to use mobile devices in other, more meaningful ways.
To compile this set of learning arrangements, the design team created various meaningful learning arrangements with ICT that accommodate differences between pupils. To evaluate Objective 1, one learning arrangement, the Dream Room, was evaluated with the teacher and pupils. The results are described below. For Objective 2, the set of developed learning arrangements was shared with other teachers at the school and outside the school, so they could also use them and be inspired to start developing such learning arrangements themselves. This is described in Section 5.3.

5.1 Evaluating the Dream Room learning arrangement

The redesigned Dream Room learning arrangement (see Section 4.2) – an exemplary learning arrangement for our design team – was implemented at *De Driemaster* and subsequently evaluated with the teacher and media mentor from the design team and with the pupils.

Evaluation by teacher and media mentor
The teacher (Koen) had positive experiences with the learning arrangement. He noticed a lot of pupil engagement: the children were constantly involved in the process. The pupils were frequently doing mathematics. Working in pairs led to many learning conversations in which pupils talked about how large the furniture should be or how much paint they needed to buy. Working with the Floorplanner software served as a good, concrete check for the pupils to test the feasibility of their designs: by working out the design in Floorplanner, the pupils independently discovered what fit into in the room and what did not, which subsequently enabled them to adapt their designs. Media mentor Barbara was present when the learning arrangement was carried out. She also noted that the pupils were very engaged: they were focused from start to finish. Their creativity was stimulated because they could come up with their own ideas on how the room should look. The many options in the learning arrangement gave the pupils freedom to work at their own level. In addition, pupils could easily review the Google Classroom instructions and information about the learning arrangement when they needed to. The pairs of pupils discussed the calculations and gave each other feedback.

According to Barbara, the challenging variant of the learning arrangement could be improved by providing the pupils with a more difficult predetermined scale instead of allowing them to choose the scale themselves. Determining a scale themselves turned out to be a bit too challenging (it was difficult for pupils to make this choice), so the pupils ultimately used the standard scale from the normal variant of the learning arrangement (1:20).

Evaluation with the pupils

After the learning arrangement was completed, the teacher (Koen) performed two group interviews with pupils about how they experienced the learning arrangement. The most important results from the interviews are shown in the box below.

Results of group interviews with year 8 pupils after completing the Dream Room learning arrangement

1. What did you think of this assignment?

Many children enjoyed it, because it is different from a normal lesson, because they could craft things, and because they could design their own dream rooms. Some children indicated that it did not feel like they were learning, but that the learning happened unconsciously. The parts of the assignment (designs/sketches, working on the Floorplanner website, crafts) were appreciated differently by different children. Some children especially enjoyed crafting, which other children preferred using the website.

2. What did you learn about calculating the scale and calculating the ratios, such as paint and flooring?

Most pupils indicated that they already knew something about calculating scale, but they learned more about it during the learning arrangement, for example because they practised more and applied the knowledge and skills in a concrete context). Pupils also indicated that they learned to calculate how much paint or how many floorboards were needed. Furthermore, some pupils mentioned that they had gained more insight into the prices of paint and flooring.

3. What enabled you to learn this?

Some pupils indicated that it was helpful for them to actually apply knowledge, that they really needed to make calculations when designing and crafting. Pupils also mentioned that they learned more because it is a fun assignment, so they paid more attention to it. One pupil said he didn't really use the scale. He didn't feel like it, so he started crafting without taking the scale into account. But, by using Floorplanner, he managed to finish his room with approximately the right proportions.

4. Do you think it is important to learn to calculate with scale?

Pupils mentioned the importance of working with scale for various applications, such as reading a map and crafting. Some children thought that whether you really benefit from it depends on what you want to become when you grow up. Several children saw that the ratio calculations for floors and walls would be important when they had a house of their own later.

5. What do you see as the difference between what we just did and working from the book?

Most pupils found the Dream Room learning arrangement more enjoyable than working from the book. They gave several reasons: it is something different, they have more room for making their own choices, and they are more actively engaged than when they are just doing sums on paper. Pupils also found that the Dream Room learning arrangement provided them with an actual reason to calculate something.

6. Do you think you can learn more about scale and ratios in the way we just did or from the book?

Pupils thought they learned more from the Dream Room learning arrangement than from the book because they enjoyed it more and therefore paid more attention, and because they were doing mathematics with a real purpose. Pupils also indicated that they will remember more of what they learned from this assignment. One pupil was concerned that with this learning arrangement he would be less well prepared for the test, because you do not realise that you are actually doing mathematics

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and therefore do not pay as much attention. Other children partly agreed with him and thought a few more sums should be included in the learning arrangement. But most children thought you learn at least as much from this learning arrangement, or even more, because it is more fun and you therefore pay more attention to it.

7. How could I have made this activity even better?

Many pupils would have liked the furniture to cost money as well, so the budget also would have to be considered for the furniture (in addition to paint and flooring). This was not the case in tis learning arrangement because it did not contribute to the learning objectives about scale and ratios. One pupil mentioned adding height in the assignment/worksheet on scale calculation, so the height of a piece of furniture should also be calculated to scale. Several pupils indicated that it would have been more challenging if the easy prices were replaced with more difficult ones (e.g. €17.70 instead of €18). According to the pupils, this aspect could also be used to differentiate. It could also be made more challenging by imposing more restrictions, such as a smaller budget.

5.2   Conclusions about the Dream Room learning arrangement

From evaluating the Dream Room learning arrangement, we conclude that – as expected – a meaningful learning arrangement with mobile devices increased pupil engagement. The pupils worked intensively and were inadvertently working a lot on mathematics. Afterwards, several pupils indicated that they learned more in the meaningful learning arrangement than in a regular lesson, or that what they learned was easier to remember.

The components of the learning arrangement seem to have contributed to these experiences. Due to the *authentic context* and the *creation* of their own dream room, pupils became more engaged and the usefulness of the calculations became clearer. *Using ICT* contributed to making the learning arrangement even more meaningful or 'more real' ('buying' flooring and paint on a website, converting a 2D design into a 3D design in Floorplanner). The *choice* that pupils had in performing the assignment (creating their own design, making their own choices in spending the budget) also led to greater engagement and motivation. Finally, the learning arrangement accommodated differences between pupils in various ways *(differentiation)*: the learning arrangement was offered at two levels of difficulty, pupils were guided in accordance with their individual instructional needs, and pupils could review the instructions at their own pace. This enabled the pupils to work at their own level.

5.3   Sharing: a set of learning arrangements

To encourage other teachers inside and outside the school to also implement meaningful learning arrangements with ICT and to design such learning arrangements themselves, the set of learning arrangements developed in this project will be shared with other teachers at school and outside the school. This will be done through meetings in which different learning arrangements are presented within the school and to the school board *St Josephscholen*. The most important design requirements for meaningful learning arrangements will also be discussed (see box below), which arederived from the design team's design requirements in Chapter 3.

Design requirements for designing meaningful learning arrangements for your own teaching practice

Learning objectives, alignment with curriculum/textbook series

The learning activities are in line with learning objectives of the curriculum/textbook series. The approach in practice may deviate from the textbook series; this is even encouraged!

Characteristics of the learning arrangement

The learning arrangement is meaningful. This means that the learning arrangements has at least these aspects:

- Context / authentic / imaginable / corresponding with daily experience or practice
- Active learning / creating / making something

The learning arrangement can be made even more meaningful by:

- Activating prior knowledge (helps to put the learning in context)
- The product of the learning arrangement is actually used (e.g. by others) or is presented to others

Form of differentiation

- Pupils are provided with choice with regard to their approach in the learning arrangement
- If possible, there are also other forms of self-direction or differentiation, e.g. regarding interests, level, time and place of learning, pace

Grouping forms

Collaborative learning, learning from and with each other

Role of ICT

- ICT provides added value to the learning arrangement (the use of ICT adds something; it is more than just a replacement for paper teaching material)
- The hardware and software are easy for the pupils to use or learn to use

Organisational aspects (duration, planning, preparation time)

The learning arrangement can replace regular lessons about the corresponding subject/learning objective. Sometimes extra time is required, such as time normally reserved for crafts, ICT or projects, or it can be part of the weekly task.

The teacher's role

The teacher mainly has a supportive or coaching role, but instruction can also be part of the learning arrangement

Assessment of learning outcomes

Learning outcomes of meaningful learning arrangements can be assessed by, for instance, asking pupils to explain what they have learned. Suitable forms include presentations, portfolios or demonstrations of products the pupils created. Regular assessments can also be used, since the learning arrangements are in line with the learning objectives from the curriculum.

The design team is busy creating a website with lesson descriptions of the developed learning arrangements, so teachers from the participating schools and beyond can use them. The descriptions of the learning arrangements aim to inspire and encourage teachers to work on this themselves and to design or adapt meaningful learning arrangements for their own teaching practice. The website will also contain the design requirements (see box) and background information about the design team. Figure 4 shows a few draft pages of the (Dutch) website.
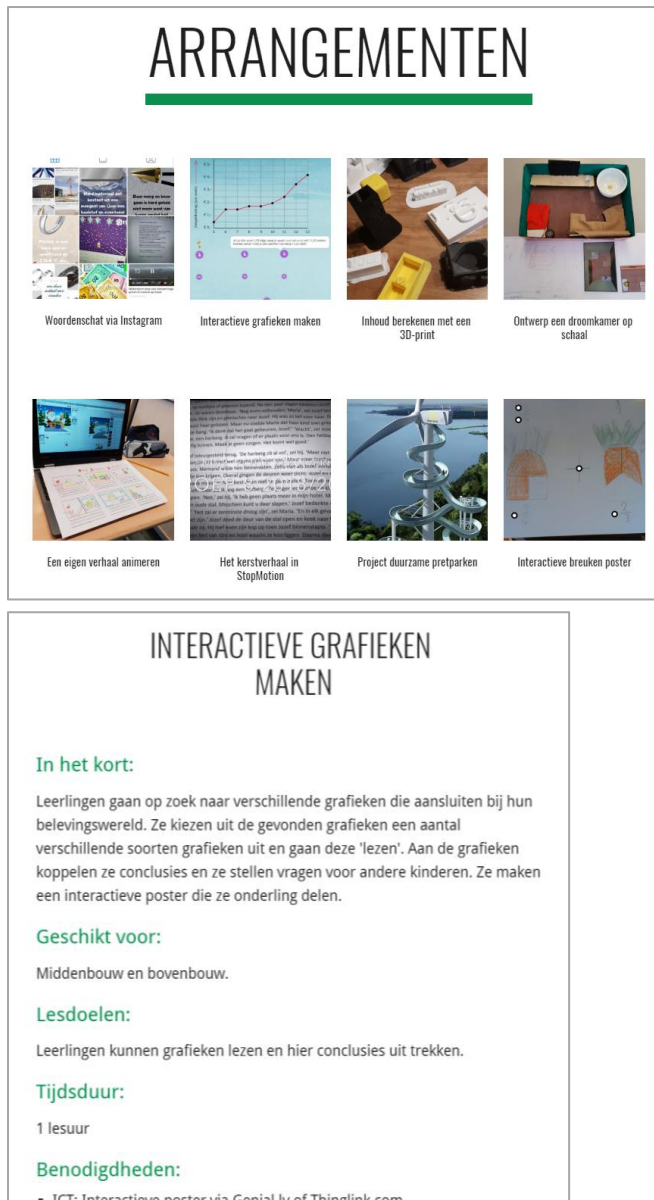
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Figure 4. Draft pages of the (Dutch) design team's website.

5.4 Design team's evaluation

The design team members had very positive experiences with the process. The teachers gained more insight into how to conduct research and how to innovate their own educational practice in a research-oriented way. They are more aware about what to look for when designing learning arrangements and how to view this in different ways, for example by using the SAMR model and the questions from the Personalised Learning Scale. Koen (teacher) noted that his perspective had been broadened with regard to personalised learning and how and why ICT can be used for this. Participating in the design team gave the teachers concrete tools to start designing learning arrangements with ICT that accommodate differences between pupils. Barbara (ICT coach) also came up with new ideas about how to use ICT in education and how to combine various ICT applications in a meaningful way in a learning

arrangement. She sees the Dream Room learning arrangement as an inspiring example that proves teaching can be done in different, more meaningful ways. Roland (teacher educator) clearly saw the connection between the pedagogical, subject-related and technical knowledge components from the TPACK model (Koehler & Mishra, 2009) come together when designing and implementing the learning arrangements. He wants to use the developed learning arrangements as examples to show his students (prospective teachers) the importance of this TPACK. The design team has also inspired him to start working more with meaningful education within teacher training.

The design team has also provided new insights into suitable methods within the design team process. The method of using of the SAMR model and the Personalised Learning Scale in evaluating an initial design of a learning arrangement and informing redesign of the learning arrangement, is now used in other iXperium design teams as well.

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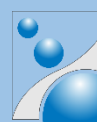Van Slobbe, P., & Van Ast, M. (2015). *Kleppen dicht.* Huizen, Nederland: Uitgeverij Pica.