

# The School Book 4.0: The Multitouch Learning Book as a Learning Companion

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**Abstract** This manuscript introduces the Multitouch Learning Book as a learning guide for school chemistry lessons. It is an e-book with integrated multimedia content, in which additional interactive materials are integrated. The use of chemistry lessons offers various advantages in terms of individual support, teaching methods and the combination of teaching with extra-curricular learning locations. Multitouch Learning Books can be grouped into the Huwer and Brünken (2018) model, which describes the dimensions of the use of digital media in individual learning processes. The first dimension describes the three operating modes of the tablet as an experimental tool, a learning tool, as well as a learning companion, the second dimension describes the methodological implementation of the tablet and the third dimension describes individualization. In addition, this document introduces the independently created Multitouch Learning Book on the topic of the particle model. During the preparation process, the current state of the art in research on the topics covered and the possibilities for individual funding was taken into account. In addition, an empirical study was conducted to investigate the influence on cognitive learning growth.

**Keywords:** *general public, middle school science, high-school, graduate education, research, collaborative/cooperative learning, computer-based learning, self-instruction, inquiry-based/discovery learning, multimedia-based learning, misconceptions/discrepant events, school book, multitouch learning book, informative and cooperative technology, IC*

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## 1. Introduction

The use of digital media is playing an increasingly important role in schools. The integration of digital media into teaching is facilitated by the advancing development of technology and the increasingly better technical equipment of schools [1]. From a political point of view, media literacy is also seen as an important cultural technique, especially in Germany. Therefore, it is "also the task of the school to establish a sound knowledge base, to compensate for deficits, to open up educational opportunities and[...] to ensure media education and media literacy as well" [2].

Digital development began in the 1980s in school lessons when special computer rooms were equipped with desktop computers. Especially for chemistry lessons, there were applications on the desktop computers for data acquisition, animation and simulation (e. g. for depicting the particle level) and various learning programs, which were kept very simple due to the technical possibilities [1,3]. From the late 1990s, more and more laptops were purchased in schools. However, they often remained in the computer rooms and were not integrated into the classrooms. The reason for this was that pedagogical and didactic expectations were not fulfilled. From around 2010 onwards, the use of laptops will be replaced by

significantly smaller and more portable notebooks, raising hopes for more collaborative and creative learning. Nevertheless, even these could not establish themselves in everyday school life [1].

The final step, which Krause and Eilks [4] call the 'digital revolution' for the time being, is the use of ICT in the classroom, which is increasingly replacing traditional computers and notebooks. Due to the technical equipment of such devices and the versatile application possibilities offered by cameras, microphones and numerous apps, the tablet is referred to as a multifunctional device in the classroom [1].

Some schools already have iPad or tablet classes in which each student has their own iPad [4]. Tablets are used in the classroom because of their practicable technical and application-related features. In addition, mobility is a significant advantage due to its relatively low weight and dimensions [1]. National and international scientific studies on the use of tablets in schools have consistently shown positive results (cf. e. g. 'Tablet PCs in the classroom', [5]). Success is not always expressed in improved performance, but often in an improved learning culture that manifests itself in the form of more independent learning, increased motivation and increased attention [6]. Especially in chemistry classes, a tablet, like other digital media, offers a wide range of applications. For example, it can be used as a digital tool to help evaluate and communicate data generated in digital form

using computers, digital data acquisition systems, cameras, graphics-enabled pocket calculators, the Internet and mobile devices. Digital media can help with static and dynamic visualizations on the particle level as well as with the documentation and evaluation of experiments.

Today's possibilities for the use of digital media, however, go far beyond the applications described previously in the case of chemistry lessons by illustrating and using digital textbooks of different categories. In particular, the Multitouch Learning Book offers various possibilities for individualization in chemistry lessons. It accompanies the learner through teaching units and replaces both the analogue textbook and the analogue exercise book. By embedding widgets - applications integrated into the book - numerous tasks, media, forms of documentation, collaborative tasks and assistance can be integrated into the Multitouch Learning Book. Particularly with regard to the individualization of chemistry lessons, there are therefore opportunities that cannot be realized with analogous materials. The tablet as a representative of the current generation of digital media forms a suitable technical basis for this.

## 2. Theoretical Background: Individualization and ICT in Chemistry Education

### 2.1. Individualization and Diversity in Chemistry Education

"The diverse developments in our society (globalisation, migration, demographic change, change in values) [...cause an increasing diversity of identities, situations and learning requirements in schools" ([7], 2013, p. 2). There are different requirements, students bring with them into class, such as age, gender, sexual orientation and national origin, but also religion, appearance, work experience and political belief [8]. In view of an inclusive school system, diversity instead of heterogeneity is required today. Both terms differ from homogeneity, in which all learners in a class are considered to be comparable and to be treated equally. While in heterogeneity, however, the diversity of learners is seen as a problem, the differences and diversity in diversity are recognized and seen as an asset. The goal of heterogeneity is integration, with the goal of diversity being the inclusion of all students [7,9,30]. The importance of diversity and inclusion is illustrated by the United Nations Convention on the Rights of Persons with Disabilities (BRK), an agreement on human rights. The BRK is embodied by eight principles: Respect for human dignity, non-discrimination, participation and inclusion, respect for the diversity of disabled people, equal opportunities, accessibility, gender justice and "respect for the developing abilities of disabled children and their identity" ([10], p. 14). The right to inclusion is therefore applicable law in Germany [10]. However, in terms of diversity, it is not only the inclusion of people with disabilities that are being pursued. Diversity also affects other aspects of diversity, such as social origin, migration backgrounds or gender [11].

The question arises as to how, with regard to diversity, the different needs of pupils in the classroom can be taken into account on the one hand, and the respective strengths on the other. So there is a need for different individualization strategies [12]. In this context, the concept of differentiation is often mentioned. Bönsch defined the term as follows in 2009:

"Differentiation is the varying procedure in the presentation and processing of learning content, on the other hand the classification or affiliation of learners to learning groups according to certain criteria. The aim is to meet the demand to offer every learner optimal learning opportunities, to secure the demands and standards in a professional, institutional and social respect and at the same time to prepare them in a learn-oriented way. For the organisation of learning processes, differentiation is presented as a bundle of measures to optimise learning from a professional, organisational, institutional, individual and social point of view" ([13], p. 14).

Generally, a distinction is made between two types of differentiation: external and internal (or internal) differentiation. External differentiation is "largely determined by the cultural and educational traditions of our society" ([14], p. 23). These include the type of school, the school profile and the year classes [14]. There are differences between school types in terms of target groups, the respective educational missions and "the underlying notions of imagery and talent" ([13], p. 17). In the case of internal differentiation, on the other hand, the content of the lessons and the learning arrangements are adapted to the group or the individual [13]. In adaptive forms of learning in particular, the goal of inclusion is aimed for, as a learning goal differentiated teaching takes place there [7].

In order to practice a meaningful internal differentiation, it is necessary to present the teaching contents with a variety of methods in many different ways. The reason for this is that the pupils have different learning talents and use different learning paths and styles. Therefore, not only linguistic but also pictorial and illustrative presentations of the contents are important. In this context, especially in chemistry lessons, references must be created between the newly learned and everyday experiences as well as to further elements of knowledge. Johnson and Johnson [15] mention the cooperative forms of learning in which pupils actively deal with the subject matter in a problem-oriented manner as a suitable method for using diversity in a class [15]. Especially in chemistry lessons, cooperative forms of learning are offered, for example in student experiments, since the students can support each other in this process [7].

### 2.2. Multitouch Learning Book

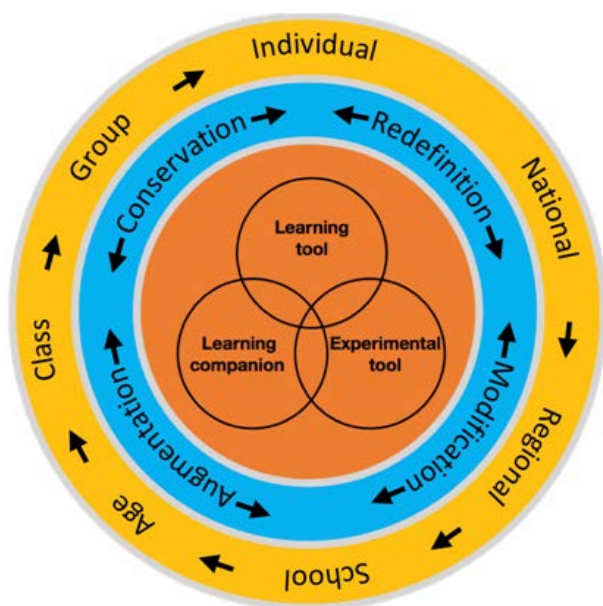
Huwer and Brünken [16] have developed a model that describes the three central dimensions of the use of digital media in individual learning processes (Figure 1).

The model focuses on the three didactic functions of tablets in the classroom. The functions are subdivided into the three operating modes 'the tablet as an experimental tool', 'the tablet as a learning tool', and 'the tablet as a learning companion' [16].

As an experimental tool, tablets offer the possibility to support experiments, for example in the form of direct measurement data acquisition, which is relevant in the natural sciences. As a learning tool, it can support the cognitive learning process in concrete situations, for example through visualization. In addition, there are various apps that help the tablet to be used in the classroom. If the tablet is used as a learning companion, it enriches the cognitive learning process over a longer period of time and ideally combines formal, non-formal and informal learning. An example of such a learning companion are Multitouch Learning books. Occasionally, hybrid modes of operation may occur [16,17,29].

This methodical implementation represents the various operating modes away from the status quo (blue circle, Figure 1):

- **Conservation** of the prevailing culture.
- **Augmentation** of existing methods by innovative approaches using ICT.
- The **modification** of student tasks that characterize the essential design of the assignment.
- **Redefinitions** in that various apps allow tasks that were previously not possible, such as the creation of short video clips using an EXPLAINistry.



**Figure 1.** Model of Individualization and didactical functions of ICT in school

The various degrees of individualization are represented in the outermost circle. The desire for an individually supported course is not new. Since tablets offer alternative ways of (chemistry) teaching due to the variety of application variants, individualization may play an important role because there is a chance for enhanced individualization at many levels including regionally relevant contexts such as language, to the creation of learning materials for individual pupils. These can range from national, regional or school level to individual classes and groups up to the individual within a class level. Huwer and Brünken [16] cite as an example the possibility of individualizing learning materials for individual students or creating an EXPLAINistry in learning groups. In addition, non-formal education offers can be networked

with formal school education in regionally significant contexts [16].

The tablet is presented below as a medium on the basis of which an application can be implemented and operated as a learning guide. In this case, the learning guide is a Multitouch Learning book, which is described below.

### 2.3. Multitouch Learning Book

A Multitouch Learning Book is an e-book with integrated multimedia content in which additional interactive materials such as worksheets and help cards are or can be integrated. They represent e-books that "can be dynamic, interactive, non-linear and modular" ([18], p. 83). Huwer and Eilks define them as "learning companions [...] in the sense of a "learning portfolio with integrated interactive elements" ([18], p. 92), which are divided into two categories. On the one hand, a distinction is made between changeable Multitouch Learning books, which can be created independently by a teacher, for example, and can thus be adapted to different target groups and needs. For this, you need a special program (e. g. iBooks Author) to create and customize it. On the other hand, there are Multitouch Learning books that cannot be changed or adapted [11,18,32]. This includes, for example, the eChemBook [21].

The advantages of the non-modifiable variant are that they can be examined and approved by the authorities in accordance with the corresponding curricula. The disadvantage, however, is that it is not possible to take into account regional references or individual class-based support requirements. Since the development time of this variant is quite long, it cannot be adapted to current events. The changeable Multitouch Learning books, on the other hand, are characterized by their flexibility in adapting to the respective class, regional backgrounds and current developments. Due to their flexibility, the books can contribute to differentiation within a class and thus support individual promotion. Since the books can always be modified, it is possible to incorporate regional conditions or current developments [18].

### 2.4. Individualization by a Multitouch Learning Book

Multitouch Learning Books offer possibilities to achieve this flexibility by adapting the content and methods. To adapt information to different types of learning, different analogue materials such as texts, images or comics [20] can be inserted in a book page at the appropriate place and displayed as required. These materials can be enhanced by dynamic visualizations, animations and videos dynamic visualizations and animations can be used, for example, to illustrate the dynamics of processes on a particle level. You can not only use different material types for the materials to be included, but you can also extend the individual types with different variants of the information display (for example, different text versions). A student can choose which variant he wants to look at, which results in a high degree of self-determination [18].

With regard to the individual advancement of the pupils, flexibility in terms of content and materials as well as the

variety of methods, for example in the selection and processing of tasks, play an important role. In the Multitouch Learning Books, students can be assigned different tasks that allow different forms of editing. Especially in the case of changeable Multitouch Learning books, it is possible to adapt the tasks to school groups or individual students [11,18]. Ulrich [11] cites as an example that a task is presented as free text, as text with word railings and also as gap text. Students can choose the level according to their individual strengths. In addition, it is also possible to implement additional aids for processing the tasks, which pupils can access at the appropriate point. These can also be offered in stages, which means that even complex tasks can be included for individual support [11]. Within the e-book, it is possible to select the aids individually since they are only displayed when a request is active. In an analogous textbook, on the other hand, all aids are presented on one page [21]. In addition, the tasks and aids in Multitouch learning books can be structured differently, e. g. as drag and drop tasks, pop-over texts or assigned tasks. This results in an appealing and playful design of the tasks, which is not possible in analogue textbooks [18]. In addition, tasks and tests can be integrated with an automatically control by the system. The advantage of this is that these tests can be repeated as often as required and thus serve for self-control. At the same time, the teacher has time to deal with problems individual. Multitouch Learning Books also make it possible to include non-linear learning pathways that are inconceivable within an analog textbook in this form. In this way, the individual learning pathways of the pupils are promoted. Hyperlinks can be used for the creation of such links, whereby according to Ulrich et al. [21] it is important to ensure that the navigation is clearly laid out and that a route to the starting point is always visible [21].

Multitouch Learning Books can also support scientific learning in Schülerlabors by "compensating for deficits in static information offers or experiment instructions in order to achieve a better networking of experimental learning with the underlying subject content" ([18], p. 81). One of the success criteria for student laboratories is their curricular networking with the school. The visit to the extracurricular learning center should be prepared accordingly in the classroom and should be followed up after the laboratory visit [22]. However, there is usually a break between the teaching materials and the materials used in the student laboratory. Multitouch Learning Books can overcome this rupture by creating appropriate networks. One possibility presented by Huwer and Eilks [18] are the Multitouch Learning books developed by an external team of authors, which are available in the form of an 'educational cloud' in different modules or contents. The teacher can assemble the modules individually according to the needs of the classes and thus select the degree of differentiation [18,28]. Pupils can also enter the experimental documentation of the experiments in the Multitouch Learning Books. This creates a network between the teaching materials and the materials from the student laboratory visit. For the student laboratory visit itself, the Multitouch Learning Book offers the advantage over the analogue form that additional media such as explanatory videos or animations can be integrated into

the materials available there. In addition, the Multitouch Learning Book also offers many possibilities for differentiation in the student laboratory, which plays an important role for the objectives of a student laboratory [18].

## 2.5. How to create a Multitouch Learning Book

For example, the MacOS software iBooks Author can be used to create Multitouch Learning books. Such software makes it possible to implement an e-book with texts and images together with widgets provided by the software or available over the Internet [31]. Widgets are "small, pre-programmed applications that can be modified by the user on a graphical user interface without programming knowledge and can be adapted to the respective application scenario" ([18], p. 89). The widgets can either be taken directly from the software iBooks author or from external platforms such as Bookry® or Learningapps® adapted and integrated into the e-book. While the widgets of iBooks Author and Bookry® in the e-book work without an active Internet connection, these are required for the widgets of Learningapps.org. The iBooks Author program offers the widgets Gallery, Media, Repetition, Interactive Image, Popover, Keynote, 3D, Scroll-Bar and HTML, where the content can be displayed directly on the book page. The gallery can be used to create an image gallery of multiple images on one image page, the Media widget can be used to insert additional videos, and the Popover widget creates a popup for a specific area on the book page. This allows you to hide text or images behind an icon. The contents of the widgets of Bookry® and Learningapps.org only become visible when the corresponding app icons are called up in the book. Bookry® offers in the form of HTML5 widgets in addition to widgets that contain "important elements[...] for scientific learning" ([18], p. 89) also includes various game widgets. With regard to gamification, for example, crossword puzzles or 4 images of 1 word can be integrated into an e-book. The widgets drag and drop for composing images, sketchpad for handwriting, notepad for typing text and the YouTube widget, which allows you to link to a YouTube video, are just some of the important elements for science lessons. The widget In Book Photo allows you to integrate your own pictures into the e-book. Widgets created by e-book authors are made available on the platform Learningapps.org, which can be inserted into the book pages. It is also possible to customize widgets independently. In addition to widgets for various assignment tasks, the platform also offers widgets for cooperative learning. This includes an integrated chat and a bulletin board, which are networked between the e-books of the pupils [18].

## 3. The Multitouch Learning Book: The Particle Model

The Multitouch Learning Book on the topic of The Particle Model presented below was designed for the eighth grade. It is a customizable Multitouch Learning book created with the iBooks Author program and

operated using tablets. Alternatively, it can also be operated using smartphones, computers or laptops. Due to various technical and didactic advantages of tablets in the classroom, however, the tablet is used as a digital tool [4,11,23]. It is a learning guide that replaces both the textbook and the textbook. Therefore, it is assumed that each student has his or her own terminal. The series of lessons was designed for six lessons, ideally double lessons. The didactic background of the teaching series is formed by multimedia learning environments of Witteck, Krause and Eilks [24] as well as the particle concept of Eilks, Möllering, Leerhoff & Ralle [25] and Eilks and Krause [26].

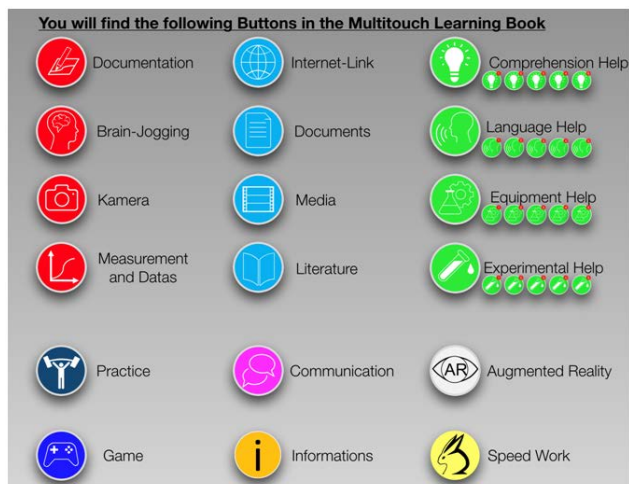


Figure 2. Icon Overview in a Multitouch Learning Book

The icons developed by Huwer, Seibert and Brünken [27] were used in the e-book to make the widgets clearer and easier to recognize. With their help, the pupils can directly recognize the category of the widget and in which level it is available. This promotes and facilitates navigation on the one hand and individual learning paths in the book on the other. The icons are divided into seven upper categories, which differ in color. This includes materials (light blue), tasks (red), tips (green), exercises (navy blue), communication (pink), additional information (yellow) and games (dark blue). The materials are divided into pictures & videos, Internet, encyclopedia & glossary and documents with correspondingly marked icons. The "Tasks" category is also divided into four types: Brain jogging, data acquisition, notes and camera. In the category "Tips" there are tips for understanding, device tips, language tips and experiment tips [27]. To make the structure of the interface transparent to the user, the icons in the Multitouch Learning Book are initially displayed as an introductory medium in an overview.

The Multitouch Learning Book is divided into five pages and a supplementary knowledge collection (Glossary). In order to make the e-book clearer, the contents of each lesson, with the exception of the third and fourth hour, are presented on a separate page. The third and fourth lessons are combined on a common page. The collection of knowledge or the glossary at the end of the book serves as a reference work on the one hand and as an aid if pupils have problems with the handling of tasks. To make navigation easy, students are guided from any section directly to the appropriate place in the knowledge

collection using hyperlinks. In this, direct links to the individual sections can be used, which makes it possible to quickly find the required information.

After an introductory lesson on the particle model, the topics of states of matter, changes in state of a matter, the dissolution process as well as particle movement and diffusion will be dealt with. These physical processes are first explained at the substance level and then transferred to the particle level, which means that a red thread can be seen through the series of lessons. In the following, the series of lessons including the widgets implemented on the book pages will be presented.

### 3.1. Page 1: The Particle Model

Entry into the classroom series is done by means of a comic strip, which is called up centrally as a popover. In order to ensure that students read the comic carefully, they should collect Democritus' thoughts with the help of the "Notepad" widget. These notes can be used for the subsequent discussion in the plenary session. Since the contents of the comic only allow assumptions about the existence of the small particles, the actual existence is justified with the help of the scanning tunneling microscope. To do this, students play the video Chemistry under the microscope using the YouTube widget, which contains a link to the video. This includes an interview with the Nobel laureate and co-developer of the scanning tunneling microscope Gerd Binnig and various visualizations of the microscope's functionality. In order to ensure that the video is watched carefully, six multiple choice questions have been added to the video.

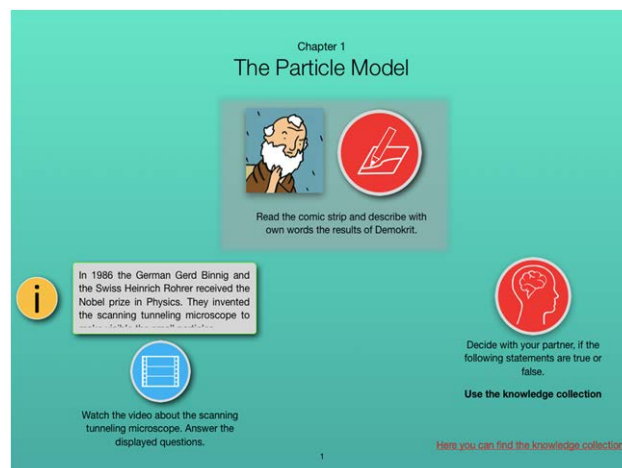


Figure 3. Chapter 1 The Particle Model

Since students do not know where the questions are displayed in the video, it is necessary to focus on the questions when watching the video. The questions are used to review and reinforce the video's most important insights. Answering can be done at an individual learning rate and individual passages of the video can be replayed if necessary. After an oral discussion of the term 'model', the pupils classify statements about the small particles in an assigned task as true or false. This gives them concrete ideas about the particle model. The relevant text in the knowledge collection contains the required information in a compact form.

### 3.2. Section 1 and 2: Aggregate States and Their Changes

As an introduction to the second hour, the teacher carries out a demonstration experiment in which the three aggregate states of the water are repeated on a material level. The documentation of the execution, observation and explanation is done by means of two note widgets, in which drag-and-drop texts are filled in and sentences are put into the correct order. The already prepared sketch of the experimental setup can be seen via a pop-up. In order to consolidate the contents, the pupils name the aggregate states of the water at the corresponding pins in pre-fabricated test sketches. In another brain jogging widget, the explanation is then transferred to particle level. In a prefabricated table, the students use drag and drop to assign properties on particle level to the states of matter.

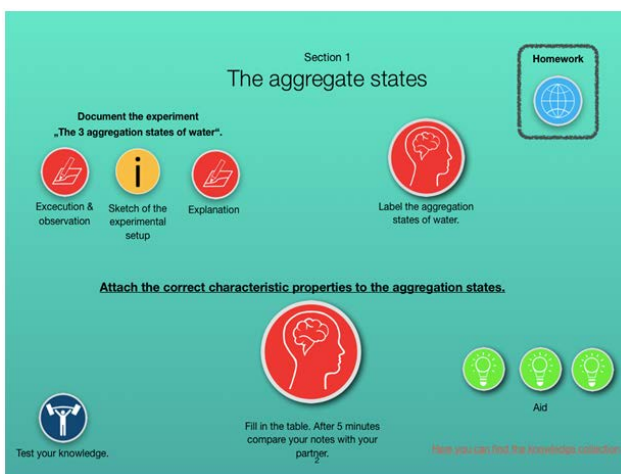


Figure 4. Section 1 The aggregate states

If it is difficult for a student to assign the relevant information, it is possible to use the collection of knowledge in which the relevant information is made available. Pupils who are able to work on the task quickly can take advantage of a training course in which aggregate states are assigned properties in a group puzzle. This will consolidate the previous task and allow students to see whether they have understood the content. In preparation for the next lesson, students will receive a homework assignment to download the free "Stop Motion Studio" app from the Internet (Internet widget). In the third lesson, the previous knowledge is activated at the material level in the same way as in the second hour. For this purpose, the students have access to a video created with the help of the programs iMovie and Explain Everything, which explains the state of matter transitions on a material level using everyday examples. The everyday examples show the pupils on the one hand that the transitions of state of aggregation are relevant in their living environment and on the other hand serve for a better understanding. In the brain-jogging widget, which is to be edited afterward, the pupils apply their knowledge acquired up to then by entering the aggregate state transitions into a graphic via drag-and-drop. Since the graph represents a circuit between the states of aggregation, pupils are also made aware of the fact that a substance can pass from one state of aggregation to another.

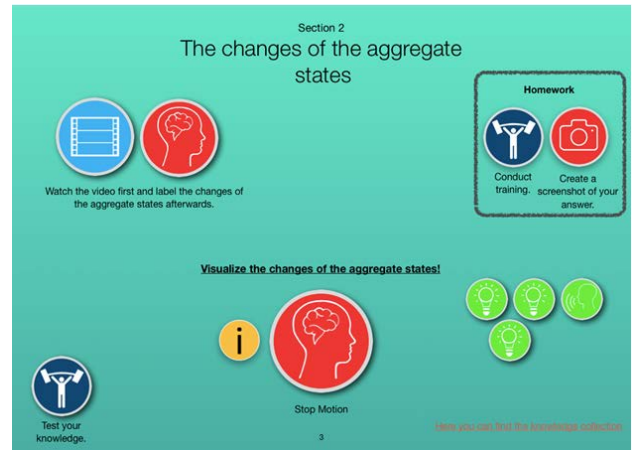


Figure 5. Section 2 The changes of the aggregate states



Figure 6. Interactive exercise for the changes of aggregate states

In order to transfer the explanation on a particle level, the next step is to develop dynamic visualizations using the App Stop Motion Studio. Since this app cannot be integrated into the Multitouch Learning Book, it is opened separately from the Ebook on the tablet. The procedure for making the films is based on the suggestions of Huwer and Seibert [17]. To visualize the aggregate states of the small particles, clay cardboard is available as a base and cellular rubber for modeling. At the same time, no specifications are deliberately made with regard to the appearance of the particles, so that one's own ideas can be introduced and realized. In addition, the pupils are informed in an additional information widget that the particles are also constantly in motion before and after the changes in the state of matter since this aspect is assumed to be ignored. For this purpose, corresponding animations created with the program Keynote are available, which show the particle movement in the aggregate states. In terms of differentiation, groups that have completed their tasks more quickly can visualize another transition or perform a training session.

The training includes a modified, cognitively more demanding version of the task in the initial brain jogging widget. The relative temperature, the aggregate states and the aggregate state transitions are to be named on corresponding markings. As soon as all groups have completed the development of the stop-motion films, the students watch the finished films together. Due to the

different appearance of the small particles, it is established that the particle model actually represents a model that simplistically depicts reality. The individual videos are critically reflected in the plenary session, which supports the cognitive study of the respective content.

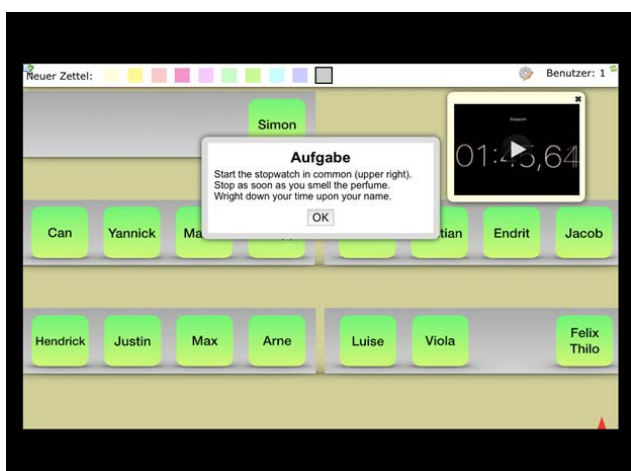


Figure 7. Collaborative exercise with the seat plan

The homework contains six animations that visualize the transitions on the particle level, which are to be connected with the corresponding names of the transitions. Once the task has been processed, the system immediately displays whether the selected solution is correct. Therefore, it can be repeated at any time for individual training.

### 3.3. Section 3: The Dissolution

The next lesson starts with a picture of tea and candy sugar with the signature "Why does tea taste sweet after a short time everywhere after adding sugar?". However, this question is not answered and serves only as an impulse. In order to demonstrate the dissolving process on a material level, the teacher carries out the demonstration experiment 'Dissolving sugar in water'.

After the students have documented it in the notes widget, they can choose between a brain jogging widget and a photo widget. The Brain Jogging widget opens the pop-up: "Create a stop-motion film that shows the dissolving process of sugar in water." This task is to be handled by the students who find the dynamic visualization helpful and who have already been able to create the stop-motion video in the previous hour without any major problems. The photo widget offers the possibility of displaying the dissolving process as static images, resulting in snapshots of the process. This task can be performed by students who have had problems creating stop-motion movies in the previous hour or who are cognitively overburdened with the dynamic explanation. The static visualization prevents overloading of the working memory. The photo widget can capture up to five images. Both types of visualization can be performed with the sponge rubber particles from the previous hour or with newly created particles. Pupils who are finished early have the opportunity to work on the other variant and experience both dynamic and static visualization. In addition, a training can be carried out which shows static images of the dissolution process that are to be put in the correct

order. The results of the visualization task are considered in class and critically reflected upon.

### 3.4. Particle Motion and Diffusion

This lesson starts with a collaborative introductory task. By opening the corresponding communication widget, a seating plan of the class in the chemistry room with its name and a stopwatch are displayed. The teacher sprays some perfume in one place in the chemistry room, whereupon the students start the stopwatch. This is stopped each time a student smells the perfume. In this case, he opens a text field and writes the elapsed time to his name in the seating plan. The result will then be discussed in class. The students realize that the perfume particles are dispersed in the room and must have mixed with the air particles. After completing the task, the teacher explains that the observed mixing is called diffusion. Since this movement is not visible to the pupils, the experiment "diffusion of bromine" is carried out under the fume cupboard. Documentation is done in the Notes widget. In order to visually document the experiment, a pupil is asked to take five photos of the experiment and send them to his fellow pupils.

The photos are uploaded in the photo widget. Pupils then check the temperature dependence of diffusion in student experiments the corresponding experimental instructions ("research assignment") can be called up in the document widget in the form of a pop-up. The experiment is documented both in writing in the note widget and visually in the photo widget. The photos can be taken directly using the photo widget and saved there automatically. Finally, the pupils will be asked to comment on the newspaper article "reduced water". For this purpose, an existing newspaper article was modified, made anonymous and given a new design for a newspaper article on the "Lehrerfreund"-website. This is opened via a pop-up. The pupils use their knowledge of the small particles to critically assess the contents of the article orally in the plenary session.

## 4. Research

The research is based on the cognitive development of the students through the Multitouch Learning Book. It was investigated whether significantly when working with the Multitouch Learning Book 'The Particle Model'. By examining cognitive development, it is determined whether the materials have been designed in such a way that the pupils have understood and internalized the contents. If a significant cognitive improvement occurs with the help of the Multitouch Learning Book, this suggests an individualization through the e-book, as not only the stronger pupils experience an increase in performance, but also the weaker ones.

### 4.1. Design

A two-group comparison plan with pre- and post-test was carried out for both studies. For this purpose, an independent questionnaire was developed, which was used in an 8th class middle school. The class is an iPad class

that works according to the 'BYOD' principle. The class originally consisted of 16 students, with one student leaving during the investigation. Thus, the test was carried out with 15 test persons. The control group worked with analogous materials for which the tasks from the Multitouch Learning Book were prepared in an analogous way. This class, which is taught at the same school as the experimental group, consisted of 27 students, with only 24 having completed the pre- and post-test. The two classes were taught by different teachers and at different times. The series of lessons in the iPad class was held from 23 October to 20 November 2017, with no chemistry lessons in one week due to a holiday. The control group carried out the series of lessons from 30 November 2017 to 12 January 2018, with the completion of the questionnaires not taking place until 19 January. Two weeks of Christmas holidays were spent during these lessons. In both classes, chemistry classes were taught in double lessons. The evaluation is carried out by means of a two-sided T-test with the same variance and a significance level of 5%.

### 4.2. Results

Table 1 shows the results of the control group cognition test. It can be seen that the mean value of the correct results in the pre-test is higher than in the experimental group. This suggests that the control group had more prior knowledge than the experimental group before the series of lessons.

Table 1. Statistic Values of the cognition tests. EG = Experimental Group, CG = Control Group

	Pre-Test EG	Post-Test EG	Pre-Test CG	Post-Test CG
Average	5.375	9.000	6.687	8.681
Standard Deviation	1.615	1.317	1.434	2.222
t-Value	-6.5989		-3.7046	
p-Value	0.0000003		0.000457	
Cohen's d	1.2254		0.535	

However, the mean value of the re-test is higher in the experimental group than in the control group. This means, on the one hand, that the experimental group has experienced a greater increase in performance than the control group and, on the other hand, that the cognition after the series of lessons is greater in the experimental group than in the experimental group. Figure 9 illustrates this relationship. The standard deviation of the control group's re-test is significantly higher than that of the experimental group. The effect strength of the control group is also large, but significantly lower than the effective strength of the experimental group. The available results suggest that the experimental group experienced a greater learning gain than the control group. However, various factors must be taken into account that can influence the results. On the one hand, the classes were taught by different teachers, which means that the subject matter was taught to them in different ways. On the other hand, the lessons were held at different times. In the control group, the series of lessons was started before the two-week Christmas break and only then completed. It

can be assumed that during this time the pupils forgot about the contents of the series of lessons, which would have a negative influence on the result of the re-test compared to the experimental group. Another important factor is the small test person size.

In order to obtain clearer results, the test person size would, therefore, have to be increased significantly. However, the difference in effect strength between the experimental group and the control group is so large that the hypothesis can be confirmed: It can be assumed that the use of Multitouch Learning books increases cognition.

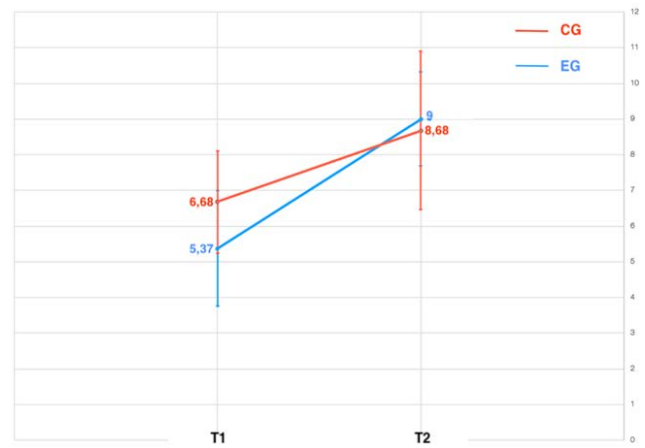


Figure 8. Results of the cognitive testing

### 5. Conclusion

In the course of the 'digital revolution', the use of digital media in schools is becoming increasingly important. Furthermore, diversity with the demand for inclusion and differentiation is a central aspect of school education. Digital media offer various possibilities to meet this requirement. The use of digital media in the classroom, using the tablet as an example, offers many possible applications from both, a technical and an individual point of view. In addition to mobility and multimedia in conjunction with suitable software, digital media offer various implementation options with regard to inclusion and, in addition, individual and cooperative learning opportunities can be used. In this work the tablet was introduced as a tool to design and enrich the lessons with the learning guide Multitouch Learning Book. The Multitouch Learning Book is an e-book with integrated multimedia content that can replace both the classic exercise book and the textbook in class. The e-book can be available in a changeable or non-changeable version. The changeable variant offers the possibility to adapt the contents to a class, regional conditions or current developments. With regard to individual support in the classroom, they are characterized by their flexibility with regard to the variety of media and methods. It offers possibilities to integrate different analog and digital media and contents into the book, but also different types of tasks and help. In particular, the integration of dynamic visualizations and animations help students to clarify explanations of processes at particle level. Such animations and videos can be adapted to the individual learning pace and can be used at any time as repetition or



preparation. This results in options that are selected according to the respective interests and strengths and thus promote self-determination, which in turn increases and promotes motivation. In addition, different presentation possibilities can be combined and tasks at different levels of difficulty can be offered. Assistance can also be used in a targeted manner and made available in a stepped form. Furthermore, it is possible to realize non-linear learning paths, which can be designed individually by the students. In the out-of-school learning environment, such as a student laboratory, the Multitouch Learning Book can create a network to the formal teaching content and offer opportunities for differentiation. The Multitouch Learning Books were designed to support research-based experimentation in experimental phases and to promote not only high-performing but also, in particular, low-performing students. Since the materials also allow differentiation within small learning groups, each student can contribute individually to the research process. Teachers can therefore increasingly take on the role of learning guides and offer targeted support. Based on the implementation of the Multitouch Learning Book The particle model in the iPad class of a Saarland high school can be confirmed that the pupils accept and use this form of materials and the associated individualization possibilities. Not only the high student participation, but also the results of the cognition test, which showed a greater increase in learning than that of the control group, illustrate the successful individual promotion with the help of the Multitouch Learning Book. Since the e-books presented can be modified, they can always be adapted to the respective learning group by implementing more or less differentiation options if necessary. It should also be noted, however, that the use of self-designed multitouch learning books also has its limits and risks. For example, it is currently not possible to integrate students' own videos into the Multitouch Learning Books using the programs and platforms described. However, this would offer added value, especially for the documentation of experiments.

The use of Multitouch Learning Books is not only conceivable in the initial chemistry lessons, but also in the middle and high school. In view of further research, it makes sense to test further widgets and programs. Possible applications include the integration of digital panel images, digital data acquisition, augmented reality or presentation programs such as Prezi. To this end, further platforms for creating additional widgets should be tested and compared with the programs presented in this paper. One possibility to design the widgets completely individually is independent programming. To help teachers create multitouch learning books, an 'education cloud' could help. This is developed by external authors and made available to the teachers. Since the modules and contents are assembled individually, the materials can be adapted to the respective class.

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