TU WIEN Informatics

Entwicklung und Evaluation der Lernplattform Studyly für den Informatikunterricht

DIPLOMARBEIT

zur Erlangung des akademischen Grades

Diplom-Ingenieur

im Rahmen des Studiums

Media and Human-Centered Computing

eingereicht von

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Wien, 4. Mai 2023

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TU WIEN Informatics

Design process of the learning app Studyly for use in Austrian Informatics school classes

DIPLOMA THESIS

submitted in partial fulfillment of the requirements for the degree of

Diplom-Ingenieur

in

Media and Human-Centered Computing

by

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Erklärung zur Verfassung der Arbeit

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Wien, 4. Mai 2023

Leon Frischauf

Acknowledgements

I want to thank...

- ... Ao.Univ.Prof.i.R. Dipl.-Ing. Dr.techn. Gerald Futschek for all the support during writing the thesis. Without his insights, guidance and discussions, this work would not have been possible.
- ... my courses with Dr.phil. Mag.phil. Astrid Weiss, Associate Prof. Dipl.-Ing. Dr.techn. Hilda Tellioğlu and Univ.Prof.in Geraldine Fitzpatrick PhD for the interesting topics on study design, interview analysis and design studies, without which I could not have done the practical part of this thesis.
- ... the teachers & students involved in this work.
- ... my colleagues at Studyly.
- ... my dad, my mum, my brother for all the support.
- ... my girlfriend Sophia for proofreading the thesis and the ongoing support during my studies.

Kurzfassung

Die stetig fortschreitende Digitalisierung macht auch vor den österreichischen Klassenräumen nicht Halt. Die Geräteinitiative beziehungsweise die damit verbundene Ausstattung aller Schülerinnen und Schüler ab der Sekundarstufe I sowie das neu eingeführte Pflichtfach „Digitale Grundbildung“ führen zu einer weiteren Beschleunigung dieses Prozesses. Diese Entwicklung verlangt Innovationen auch bei der Unterrichtsgestaltung respektive bei den Unterrichtsmitteln.

Die vorliegende Arbeit stellt sich dieser Herausforderung und versucht, die digitale Lernplattform Studyly, welche sich bereits für den Mathematikunterricht etabliert hat, an den Informatikunterricht der fünften Klasse AHS anzupassen.

Nach einer Bestandsaufnahme des aktuellen Informatik-Lehrplanes wird der Unterricht von Österreich mit Estland verglichen, einem Vorreiter der Digitalisierung. Um nun für den Informatikunterricht eine digitale Plattform zu entwickeln, wurden in einem ersten Schritt notwendige Voraussetzungen für digitale Plattformen diskutiert - sprich was gegeben sein muss, damit eine solche Plattform gut in den Unterricht integriert werden kann. In einem zweiten Schritt wurden unterschiedlichste Plattformen in Hinblick auf einen potentiellen Einsatz für den Informatikunterricht analysiert, wobei schlussendlich die Entscheidung auf Studyly gefallen ist.

Schließlich wurden im Rahmen dieser Arbeit zu fünf relevanten Themenfeldern Unterrichtskonzepte erarbeitet - welche dann auch exemplarisch auf Studyly abgebildet wurden. Die Themenfelder reichen von Verschlüsselung bis hin zu Datensicherheit oder künstlicher Intelligenz. Um den praktischen Einsatz der Lernplattform zu analysieren, wurden sowohl qualitative Interviews mit Lehrpersonen als auch eine quantitative Erhebung mit Schüler:innen durchgeführt.

Diese Resultate zeigen eindeutig den Mehrwert, den digitale Lernlösungen für den Informatikunterricht bringen können (Motivationssteigerungen und bessere Lernerfolge), geben aber auch ein gutes Feedback über die weiteren notwendigen Schritte für eine spätere Vollausbaustufe. Denn das soll genau das Ziel der Arbeit sein: Ein vollständiges Konzept darzulegen, wie - in Kooperation mit einem führenden Schulbuchverlag - der Informatikunterricht „revolutioniert“ werden kann.

Abstract

The steadily advancing digitalisation does not stop at Austrian classrooms. The device initiative and the associated equipment for all pupils from lower secondary level onwards as well as the newly introduced compulsory subject "digital basic education" are leading to a further acceleration of this process. This development also requires innovations in the design of lessons and teaching materials.

This thesis takes up this challenge and tries to adapt the digital learning platform Studyly, which has already been established for mathematics lessons, to the Informatics lessons of the fifth grade AHS.

After taking stock of the current computer science curriculum, the teaching in Austria is compared with Estonia, a pioneer of digitalisation. In order to develop a digital platform for Informatics lessons, the first step was to discuss the necessary prerequisites for digital platforms - i.e. what must be given so that such a platform can be well integrated into lessons. In a second step, a wide variety of platforms was analysed with regard to their potential use in Informatics lessons, and Studyly was chosen.

Finally, within the framework of this work, teaching concepts were developed for five relevant subject areas - which were then also exemplarily mapped on Studyly. The topics range from encryption to data security and artificial intelligence. In order to analyse the practical use of the learning platform, both qualitative interviews with teachers and a quantitative survey with students were conducted.

These results clearly show the added value that digital learning solutions can bring to Informatics teaching (increased motivation and better learning outcomes), but also provide good feedback on the further steps necessary for a later full development stage. For that is precisely the aim of the work: to present a complete concept of how - in cooperation with a leading textbook publisher - Informatics teaching can be "revolutionised".

Contents

CHAPTER 1

Introduction

1.1 Digitalization in Austria

Austrian schools, like many others globally, are undergoing significant changes due to the increasing emphasis on digitalization. This poses particular challenges for the Austrian school system, which must be met with the appropriate measures. Already in 2017, a step into this direction was made through the digitalization strategy "Schule 4.0 - Jetzt wird's digital". Since then, through the subsequent "8-Punkte Plan" and the circumstances brought about by the Corona pandemic, decision-makers became aware that the digitalization of teaching is an urgent necessity. Via the device initiative ("Geräteinitiative"), all schools throughout Austria from secondary level 1 onwards have been successively equipped with digital devices since the school year 2021/22. Accordingly, schools are faced with the challenge of using these devices reasonably and to the benefit of students. As there are currently few digital offerings adapted to the curricula (especially in Informatics), various providers have been trying to meet this need for some time. However, most of these are "island applications" that cover only some aspects. Based on these circumstances, Studyly has already set itself the goal in 2019 of developing a platform for mathematics that includes all relevant teaching aspects: In addition to digital tasks and their automatic correction, the independent practice and learning shall be in the foreground. Furthermore, a specially developed algorithm ensures that learners are provided with the most suitable tasks at a given time, considering the individual level of knowledge and enabling individual learning for students.

1.2 Research questions

Based on this experience with Studyly for mathematics, we aim to use this digital learning platform also for other (scientific) subjects. Consequently, it is crucial to transfer the

concept of Studyly to Informatics teaching, whereby the technology should always follow the content and not vice versa.

Taking into account this subject matter and the evaluations performed, the following research questions arise:

- Q1: What Informatics content is needed in terms of a concrete implementation strategy as well as a subsequent actual implementation?
- Q2: How should the interactive tasks on Studyly be designed to maximize student learning of Informatics as a school subject?
- Q3: After the pilot application has been completed, what strengths and weaknesses can be derived for further development steps?

The first research question's framework (Q1) aims to didactically prepare suitable subject areas for Informatics lessons on Studyly. A corresponding concept for each of these areas, is developed as part of this question.

The second question (Q2) deals specifically with the matter of how the content should actually be implemented. This involves deciding which digital possibilities for presenting the learning material shall be used.

Finally, a qualitative survey will try to provide an answer to the last research question (Q3): Studyly will be used in five different school classes as part of regular lessons to get student's feedback, which will be then used at a later point to improve the platform alltogether. In the course of this, a qualitative survey will be carried out before and after use with selected teachers as well: The goal is to understand the teacher's general expectations and how Studyly is actually used in classes.

1.3 Structure of the thesis

Firstly, Informatics teaching will be covered in detail before taking a look at Estonia, the European pioneer of digital development. Based on this case study, a concept for Informatics teaching in Austrian schools will be considered. In this context, we will discuss five subject areas that will be implemented on the platform.

Subsequently, a didactic concept will be developed for each of these five subject chapters and implemented on the learning platform. As a wide variety of components, such as gamification or the question design process, play a crucial role in the pupil's learning process, these areas will be explained. Furthermore, a comparison of different platforms is followed by arguments favoring using Studyly for Informatics.

Afterwards, the piloting strategy and its background will be stated - before describing the exchange process with the teachers and the concrete use of Studyly in the classroom. This will allow us to gain corresponding insights based on qualitative survey methods:

For example, feedback from the students is included in this thesis, as this is particularly valuable for the further development of the Informatics aspects of the platform. In a final step, by means of an outlook, it is pointed out how an even more intensive use of Studyly for Informatics lessons can be facilitated in the upcoming years (and necessary changes that have to be made to the platform).

In the context of this research, reference is made not only to the relevant literature such as "Didaktik der Informatik. Grundlagen, Konzepte, Beispiele" by Peter Hubwieser ([Hub07]) but also to "Dimensionen der Medienkompetenz" by Six and Gimmler ([Gim12]) etc. Concerning how the relevant learning content of Informatics should be represented in the best possible way, one is guided by Bruder and Sonnberger ([BS08]), who have dealt intensively with this research area of exciting digital teaching. For the empirical survey, e.g. "Qualitative Social Research. An Introduction." by Flick ([Fli07]) has been considered.

CHAPTER 2

Informatics teaching in Austria

Before a concrete implementation strategy for using e.g. Studyly in Informatics teaching can be discussed, this chapter is dedicated to the background, developments, and challenges that Informatics teaching is currently facing in Austria. Due to the rapid (digital) development, it is made clear that it is necessary to look beyond one's horizon in order to be able to offer young people at Austrian schools a digital learning platform that demands to keep pace with the rapid developments in the field of Informatics.

2.1 From the early stages to the last curriculum amendment (2017/18)

Informatics has been integral to the ninth grade for more than 35 years - it has been established by Helmut Zink in the school year 1985/86 [BFM+10]. This has been rather surprising for the school system, so there was a lack of specialised teachers. Therefore, a lot of physics or maths teachers were holding Informatics classes - they got their didactical knowledge from special trainings at universities or pedagogical colleges ("Pädagogische Hochschulen"). Only at a later stage, specialized university studies ("Lehramtsstudien") have been introduced.

According to Mittermeir [Mit10, p.56ff], the importance was initially not in terms of actually using a computer (like text processing), but instead computer programming (in BASIC, Pascal, LOGO etc.). Due to this connection with the industry, when creating the curricula, there was a cooperation between the Ministry of Education, the social partners, and the respective industry.

Subsequently, the further development of the Internet stimulated a discussion about the areas in which a general secondary school (in German: Allgemeinbildende höhere Schule, abbreviation: AHS) should distinguish itself from other schools and what such a higher

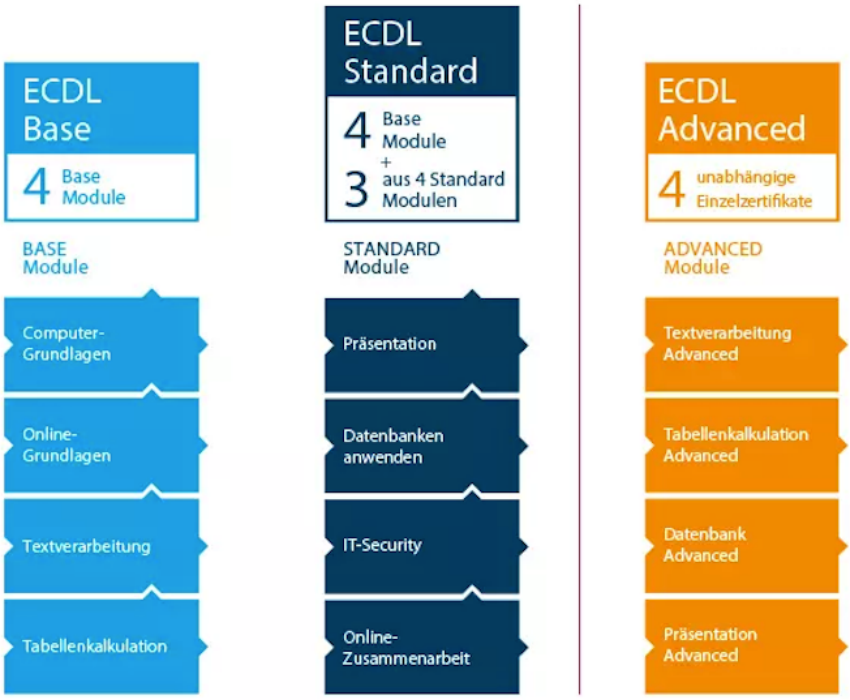


Figure 2.1: Different modules of ECDL [G]

education school should actually stand for. In this context, a discussion was initiated on how Informatics lessons should be designed.

Despite these considerations, the focus remained to application-related software (such as Word, PowerPoint, and Excel) and (therefore) still followed the industry's interests. Via this, the different modules of the ECDL curriculum (see Fig. 2.1) allowed the teachers to partly cover the curriculum of Informatics. In this context, ECDL was established in 1997. From 1998 onwards more and more schools started to offer ECDL to their students.

A similar discussion was also initiated by Peter Micheuz [Mic09, p.244]: After the revision of the curriculum in 2003, there has been an even more significant heterogeneity in all school subjects, especially Informatics. Since then particularly, schools have been able to decide for themselves the focus of their teaching (within the framework of their autonomy).

When looking into the curriculum of 2003 as well as the following one in 2013, the following issue occurs: It is relatively abstract and the teachers do not know what is to be taught in concrete terms. For example, the formulation "insights into the essential terms and methods of Informatics, its typical ways of thinking and working, its historical development as well as its technical and theoretical foundations" [Mic] leaves much room for interpretation.

Figure 2.2: Tagcloud of what pupils think of Informatics classes [Mic09, p.251]

The results of a survey conducted by Peter Micheuz in 2009 [Mic09, p.251] prove that the teachers at that time still designed their lessons with the ECDL modules in mind and that the possibilities of school autonomy were not taken into account fully. This is also confirmed from the pupils' point of view because "Word", "PowerPoint" and "Excel" in particular, are the most familiar terms to the pupils at that time. Thus (as probably still today, author's note), the topic "Standard software" was still the focus of interest in the fifth grade of the AHS, Micheuz continues [Mic09, p.253]. A recent survey of what teachers present in classes provides similar results. [MSESa] However it is important to note, that ECDL and the curriculum of Informatics have always been independent of each other - with the teachers covering some aspects to fulfill curriculum requirements.

The Fig. 2.2 illustrates that Microsoft Office programs are still associated with Informatics lessons. In addition, enthusiasm is not necessarily related to these areas as such. Nevertheless, at the same time, more than 60 percent of the teachers are focussing their lessons on this content. Beyond this "office training", areas such as "getting to know automata, algorithms, and programs" or "web design" and "databases" are treated less intensively [MSESa]. Consequently, interested pupils are confronted with Informatics-heavy topics only in elective courses ("Wahlpflichtfach") or the Informatics olympiad ("Informatikolympiade").

In 2012/13, there was a general competence orientation in all subjects - due to a redesign of the curricula - including Informatics lessons, which also accelerated a revision in 2017/18. This revision is based on the four main subject areas [MSESb]

- Informatics, People and Society
- Computer Systems
- Applied Informatics
- Practical Informatics

In the field of "Informatics, People and Society", there is an ongoing discussion about the interplay between computers and society, exploring the ways in which technology shapes our lives and the challenges individuals face as a result. The subjects of data protection, security, and copyright are critically examined, and the evolution of Informatics is traced, including the various areas of application.

In the context of "Information Technology Systems", technical aspects are essential: For example, the structure of digital end devices, the functioning of such systems, or the general functioning of operating systems are considered. [MSESb]

The practical aspect of Informatics is complementary to theoretical Informatics and covers topics taught at the university level (at the beginning of entry lectures). This includes learning and understanding terms and concepts, being able to explain, design, represent, and implement algorithms, and having a basic knowledge of automata, algorithms, data structures, and programs. Additionally, the practical component should encompass the use of databases and the creation of data models.

Only in the area of "applied Informatics" (previously known as "handling standard software") user programs for text creation, spreadsheets and multimedia presentations are discussed. [MSESb]

2.2 Today's Informatics teaching and the introduction of "Digital Basic Education"

Based on information gathered from teachers through informal conversations by the author and the above discussion, it is currently observed that Informatics classes still mainly focus on "Word", "PowerPoint", and "Excel".

However, the future might bring changes to this structure with the introduction of a new subject, "Digital Basic Education" ("Digitale Grundbildung") [fBWuF21a] for grades 5 to 8, which includes at least one dedicated lesson per week. This new curriculum, referred to as the "Frankfurt Triangle", looks at the curriculum content from three different perspectives.

- How do digital technologies work?
- What social interactions result from their use?
- What options for interaction and action arise for pupils?

The curriculum of "Digital Basic Education" is now focused on explicit applications such as standard software and the general use of computers, serving as a preparation for later Informatics lessons.

As a result, every pupil in the Austrian school system is now exposed to "computer-related" content at a relatively early stage in their life. In the course of introducing this new school subject, this has sparked discussions among stakeholders about the appropriate content to be covered. This discussion results in the conception of new textbooks, such as "vernetzt - Digitale Grundbildung" (öbv-Verlag), which conveys a sense of optimism. It can be expected that the teaching areas may continue to evolve and the process is not yet complete. [Fik22].

Comparing a traditional textbook [Fik22] with a digital textbook such as SchuBu [WMUSP22] reveals similar subject areas covered, such as basics of computer use, internet, and programming. However, in the print version, for example, the focus is clearly on the creation of texts, presentation, and tables. Thus, these three chapters make up almost half of the entire textbook. In contrast, in the digital version on SchuBu, these areas are presented as subchapters within the "Digital Work" topic block.

Since the university course at the teacher training colleges has just started, it is still being determined which areas teachers prefer to teach and how the corresponding teaching materials should be developed.

2.3 Prognosis of the future by ARGE Informatics

The Federal ARGE Informatics ("ARGE Informatik"), the association of Informatics teachers in Austria, has made a prognosis concerning the further development of the Informatics curriculum [MSES18], considering digital basic education. According to the prognosis, applied Informatics will probably move more and more into the background. This is because the related content (standard software) is explicitly covered at lower levels, as it is already addressed in many cases by "Digital Basic Education".

This means that the other areas ("Informatics, People and Society", "Computer Systems" and "Practical Informatics") can now come more into focus. There is also the possibility of including additional subject areas in the curriculum of the fifth grade of AHS: ARGE-Informatik suggests giving greater consideration to topics like "security," "big data," "media Informatics," "computer graphics," and "artificial intelligence".

Consequently, it can be assumed that Informatics teaching will highly likely have changed in a few years. In the course of implementing Studyly in Informatics teaching, precisely this evolving trend shall be taken into account.

2.4 Digitization of the school system: The role of Informatics teaching

As already discussed in the previous subchapter and as can already be observed in many other European countries, Informatics teaching has already had a significant bridging function for different subjects. Due to the successively growing importance of Informatics as a school subject for the society of the 21st century, the use of digital end devices is increasingly being shifted to other subjects. [Mit10]

The examination of how digitalization has already impacted school systems in other European countries, using Estonia as an example, will now be discussed to derive corresponding predictions for Austria and to expand beyond the prognosis made by the ARGE Informatics. Due to the current highly disruptive situation caused by digital basic education, it is essential to broaden the horizon to other countries right now so that content currently being developed for Informatics teaching can still be used meaningfully in the future.

2.4.1 Digitised teaching using the example of Estonia [Goe19]

The Baltic country Estonia is seen as one of the leading countries in terms of digitalization at the government level (see Fig. 2.4) and, more specifically, in the field of schools. This fact has several reasons, two of which are given below:

- By combining data from different sectors of the economy, there is unprecedented interconnectedness in various areas of society. For example, if a new insurance contract is to be concluded, the insurance company can automatically request necessary documents from the authorities after the customer has given his consent. A causally highly complex process could thus be significantly simplified. Different data are only stored in one place, but the so-called "X-Road" (see Fig. 2.3) enables a corresponding link at any time. Every data request is stored, and every person can check at any time who requested which personal data, hence addressing the interest of transparency.
- In addition, Estonia has an ID card, with which the most diverse forms of identification are combined. Among many other advantages, this fact has made online elections possible (since 2003). The voter identifies himself with his ID card as well as with a self-determined PIN. To avoid any form of abuse, the entire procedure is secured via several layers. For example, when voting, the identity must be proven utilizing a camera. Over the years, this online voting service has become increasingly popular: in 2017, one-third of eligible voters opted for this form of voting.

Therefore, Estonia can also be seen as a role model in digitalization. The author of this thesis was personally experienced with the technological advances in the field of

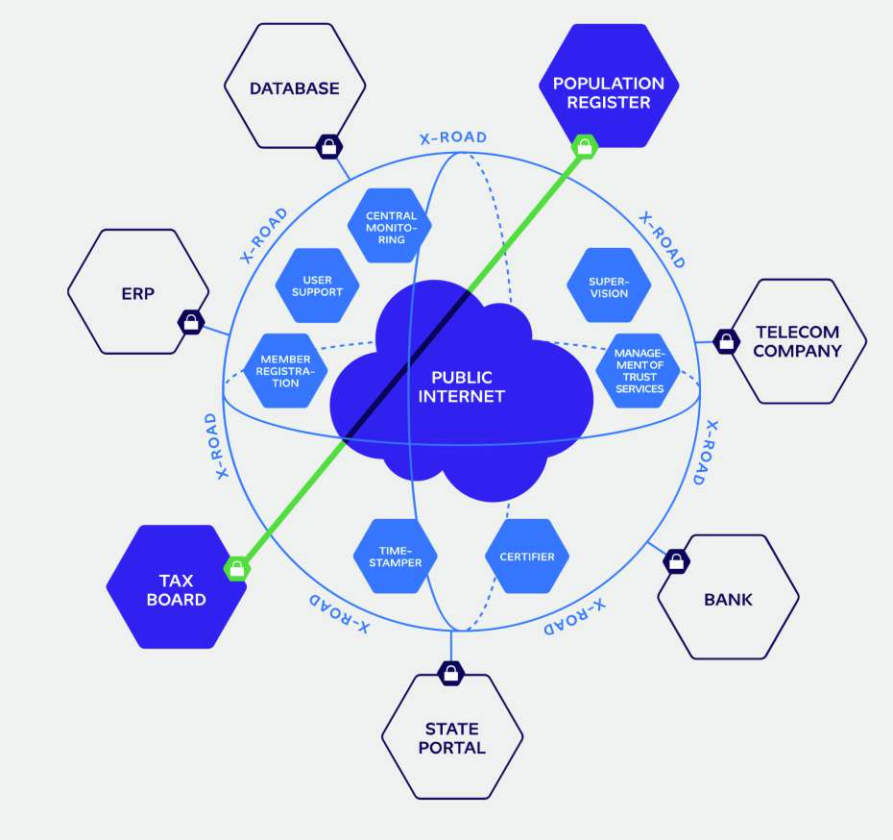


Figure 2.3: x-road: data exchange platform in Estonia [oE]

Figure 2.4: Different government areas which can be accessed online [oE]

education and the school system in connection with an educational trip by the Austrian Chamber of Commerce ("Zukunftsreise EdTech Fokus Schule"). Among other things, it is remarkable that already in the context of teacher training, digitalization is given substantial importance, and every prospective educator is confronted with it from the very beginning [Goe19].

In primary schools in Estonia, programming was taught on a trial basis ten years ago as part of the "ProgeTiiger" training program. The so-called "Tiger Leap Foundation" is behind this education program, which is characterized by close cooperation between industry and the Ministry of Education [Eis]. This piloting was highly successful, as 98 percent could be reached with this initiative. Therefore, this program was also extended and continues to be very well received [Ros12].

It is worth mentioning that all classrooms, without exception, were already equipped with smartboards at the time of the educational journey. In the area of textbooks, too, the focus is on digitalization: With the increasing trend towards digitalization, it is not surprising that more than half of the textbooks used are in digital form and do not have a print version.

This shift towards digital education materials has already taken place in many countries and it is likely that similar developments will occur in other countries as well, including Austria.

CHAPTER 3

Requirements for digital platforms

Having reviewed Estonia, our focus will now shift towards examining the specific requirements for a successful implementation of digitalized teaching. In connection with the acceptance of a learning platform on the part of both teachers and students, some central aspects must be considered. First of all, general requirements for a learning platform will be discussed before some platforms are compared with each other at a later stage.

3.1 Content-related aspects

Relevant papers of Christian Kreidl (2011) [Kre11, p. 59ff] as well as Hilbert Meyer (2005) [Mey16] will be used as a basis for the following discussion concerning content requirements. Kreidl's explanations were conceived for the higher education sector (e.g., university level), which is why those aspects had to be derived to the school sector.

As a first step, above all, the didactic conception and the organizational structure are decisive for the learning success of such applications (see also Fig. 3.1). Kreidl refers to Posch and Schneider when he states that providing problems and learning occasions for problem-solving is necessary [Kre11, Posch & Schneider as cited in p. 59ff]. Especially in the school sector, it is essential to clarify the meaning behind the respective learning content to the students so that they also deal with the subject area accordingly (reasonable entry points).

The introduction of new subject areas is crucial as it determines the level of interest and attention paid to relevant content sections that follow. Thus, it plays a central role in ensuring the success of the digitalized teaching initiative. At the same time, Meyer also confirms these premises of goal-oriented teaching [Mey16, p. 55ff]: he considers the comprehensibility of the tasks, plausibility of the thematic course, and different aspects of securing results as essential prerequisites.

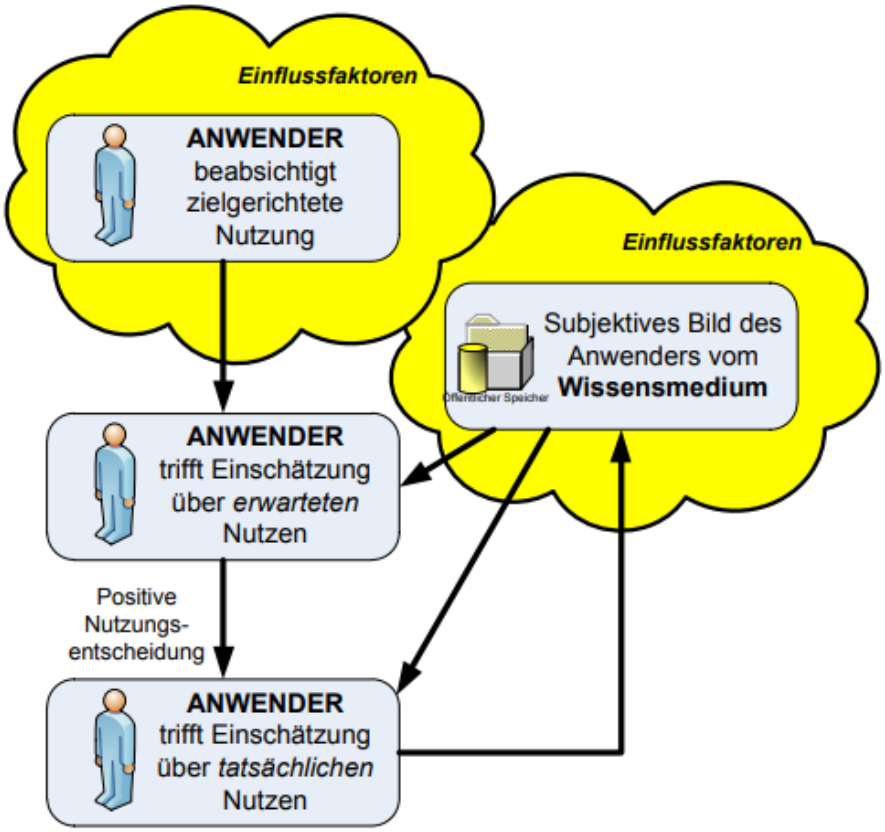


Figure 3.1: Acceptability model [Kre11, p. 49 cited by Simon 2001, p. 105]

Meyer goes on to say that it is crucial for learners to be able to see their individual results immediately after completing the respective tasks. Finally, according to the expert, personal support to the user is crucial: each user shall receive assignments adapted to him- or herself, which seems indispensable in connection with e-learning platforms. If one thinks of a print world, flexible learning materials had to be adapted in order to take over this role.

Michael Hack confirms the importance of choosing the right level of difficulty of the respective content for the students. In addition to the adequate level of the content, the prior knowledge of the students to be taught must also be taken into account. Traditionally, the fifth grade in a secondary school (AHS) was the first encounter with Informatics for most students. This created a diverse group of students for the teacher to address in their first upper school class (great heterogenity). [Hac05, p. 35-39] As concluded in the previous chapter, it is quite conceivable and expected that a homogenization of the different performance levels would be observed through the new subject "Digital Basic Education".

Nevertheless, there will always be some young people who are particularly interested in

Informatics regardless of the school context. For this group, too, it should be possible to provide the learning content accordingly utilizing individual (digital) support. In particular, a wide variety of approaches, such as the use of pictures, video sequences, and interactive graphics, are suitable for this purpose (presented as excursus). Depending on the level of proficiency, it is possible to present the related content in this interactive way within the framework of an interactive digitized teaching process. Above all, providing users with an individual task is vital in this respect, which will be discussed later in this thesis.

3.2 Organisational-supporting measures

The previous explanations clarified the necessity of a corresponding digital offer and how this must look in order to be accepted. This fact obliges an e-learning platform to provide a support service for the professionals (Informatics teachers). Experts agree that e-learning is often doomed to fail unless basic support or assistance is offered when problems occur. In this respect, technical support, which is also available at all times, is of central importance. [Hac05, p. 39]

The author's experiences support the aforementioned assumptions: Ensuring a seamless integration of those digital platforms requires ongoing and comprehensive support from schools and their teaching staff, along with comprehensive initial training. Rapid resolution of any issues or questions that arise is becoming increasingly crucial. Cooperation with relevant educational institutions, such as teacher training universities (PHs in Austria for example), is also essential to achieve success.

3.3 Technical aspects

To maximize the potential of an e-learning platform, it is crucial that it can seamlessly integrate with other platforms. This ensures that students only have to register once and can access tailored exercises on different platforms that cater to the specific needs of different subjects. The technology that makes this possible is known as IMS LTI [ACL+21]:

Suppose a platform allows it to be integrable (and therefore acts as an LTI provider by offering its service via the web). In that case, this service will receive the activity context (course, group, activity id) as well as the authentication of the LMS when launching the specific web service. This enables the external service to report results, grades, or learning outcomes to the LMS and store all the data in one place.

It is worth noting that all major LMS platforms, such as Moodle, Canvas, Sakai, Blackboard, and others, support the LTI standard. As a result, learning platforms such as Studyly can be easily integrated into them, providing a seamless and efficient learning experience for students [ACL+21].

3.4 Motivation through gamification

Gamification has a significant impact today, despite its recent origin. Companies use it to improve user experience and motivate users, leading to more time spent on their websites or services. It's not just limited to (business) education but also impacts other sectors, such as health. Gamification drives engagement and motivation and can positively change user habits. In this context however, the focus will solely be based on the aspects in the e-learning industry.

3.4.1 What is gamification?

In [Gro12] gamification is described as the "the use of game design elements in non-game contexts". This means implementing various elements typically found in computer games to other contexts in order to boost motivation and enhance user retention.

A recent study by [KY21, p.20] suggests that today's students are digital natives who have grown up with technology. However, the education sector has yet to fully embrace technology. The trend towards personalized teaching methods and various learning styles make gamification a viable solution for enhancing motivation and engagement among students.

The current coronavirus pandemic has resulted in the closure of educational facilities, leading to a shift towards online learning. In response to this, there has been a rise in the popularity of gamification applications that utilize game design elements to increase motivation similar to actual games.

3.4.2 Types of gamification

Gamification can be broadly categorized into four main types with various subtypes. Firstly, non-gamified, which includes real-time feedback and continuous score reporting to improve user engagement. Secondly, competitive gamification, which features leaderboards and comparison of scores with others. Thirdly, adaptive gamification, which involves personalized narratives, competition and services based on individual performance. Lastly, collaborative gamification that usually takes the form of group competition, narratives and leaderboards. [JBS18]

3.4.3 Different game mechanics

As it will be discussed in this section, gamification involves using various methods such as badges, customization, levels, points, and leaderboards to increase engagement and drive desired behavior. In the following section, the impact of these game mechanics will be further explored, and their usage will be linked with the different types of gamification.

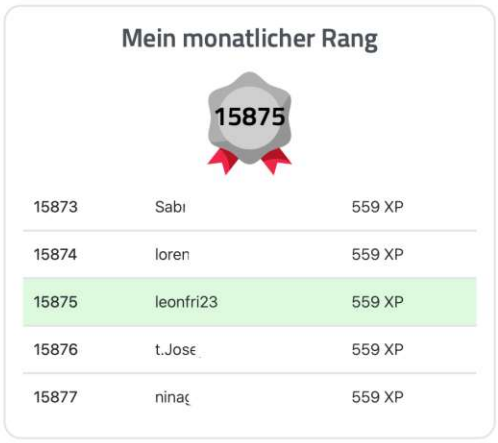


Figure 3.2: How leaderboards are represented on Studyly [Fri]

Leaderboards

One of the most common methods applied in gamification is the use of leaderboards: A leaderboard is a list of all users indicating their number of points-allowing users to rank and compare oneself with others.

Being able to compare oneself with others increases one's natural competitiveness, thus allowing users to set and pursue their own goals, which naturally impacts their behavior on a platform.

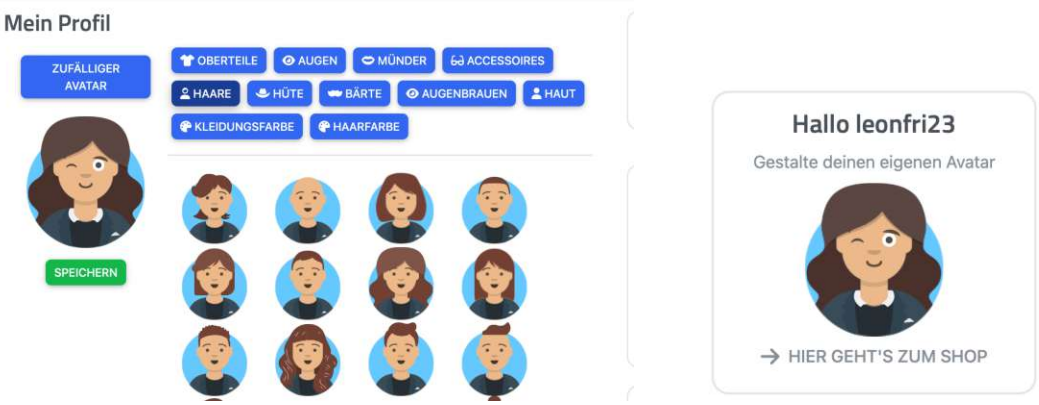
The effects of this type of incentive system can be compared to classic goal setting having a similar impact on users. Moreover, the leaderboard condition will lead users to show greater commitment and its integration will eventually improve users' overall performance. However, since using competition in primary school activities is quite complex, an empirical study concluded that the use of leaderboards alone was not sufficient. Hence, an integration and combination of various game-based elements is needed in order to improve individual performance. [JBS18]

See in the example of Fig. 3.2 how leaderboards are implemented e.g. on Studyly.

Badges

Undoubtedly, one immediately associates gamification with badges. These are small awards representing trophies in the form of icons which represent the user's accomplishments.

Empirical evidence showed that this type of rewarding system fosters user engagement as well as goal commitment. It is common knowledge that game developers often resort to introducing badges, which lead to better reception and increased revenue. [ENA16]



(a) Shop for avatar pieces [Fri] (b) Own profile [Fri]

Figure 3.3: Pupil's perspective

A common problem associated with badges is that individuals tend to prioritize tasks that yield these rewards, often to the detriment of other important activities. This is also seen on e.g. Studyly, where students solve only those tasks connected with the obtaining a badge.

Avatars

Since many people tend to be concerned about how they are perceived by others, gamification introduced avatars. These are anonymous virtual representations of users and can often be customized, working as a virtual reward system. Effects of social relatedness can be observed since many users often feel connected and attached to the avatar [JKM+21]. According to research especially people with lower imagination/openness scores are likely to prefer using avatars. [JXKV16]

See in the example of Fig. 3.3 how avatar creation processes are implemented e.g. on Studyly.

Levels

Levels in a game provide a sense of progression and advancement for the player. The accumulation of experience points, often referred to as XP, is a commonly used method to implement levels in a game or a platform. As the players collect a certain number of XP points, they are given access to the next level. This serves as a way of tracking the player's progress and showing their growth within the game. [GVH17]

Despite an ongoing debate within the gamification community whether the use of levels might even decrease the user's motivation, findings suggest that the implementation of levels, which function as progress indicators, in non-game contexts has no negative or even a positive impact and improves overall performance [MBOT13].

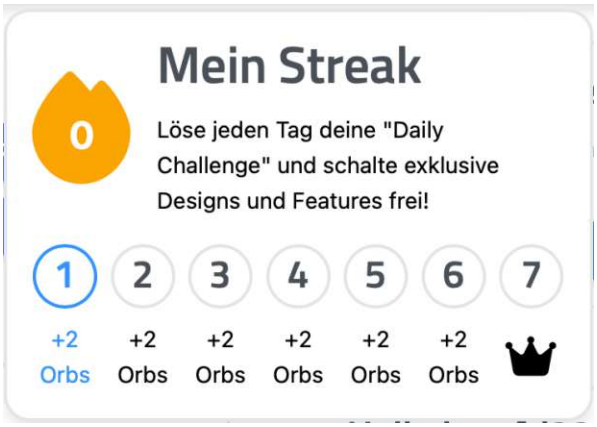


Figure 3.4: Daily challenge to collect "orbs" [Fri]

Currence / Virtual goods

Virtual goods are items that hold significant or monetary value, and can be collected, used up, or utilized to personalize the player's character. They can include in-game currencies and special items such as bonus experience points, redeemable points, or the ability to reattempt a question. Some virtual goods may only become available to the player at a later stage, subject to certain prerequisites. [KOGP18]

On Studyly for example, pupils can collect "orbs" (see Fig. 3.4) by completing their daily challenge regularly. Those "orbs" can be exchanged for clothes pieces in the shop.

CHAPTER 4

Studyly and comparable learning platforms

The previously discussed factors were carefully considered during the development process of Studyly, a mathematics platform. As the author of this paper is the founder of this project, Studyly will be discussed in a first step. Afterwards, other providers in the field will also be covered, leading to a final decision on the chosen platform.

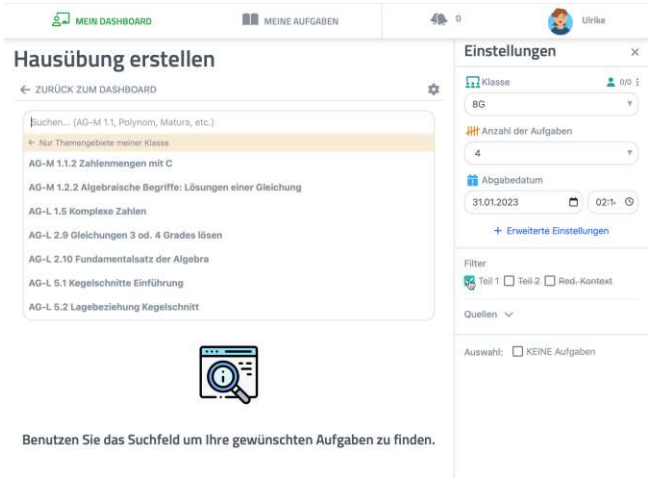
4.1 Introducing Studyly

Studyly (see Fig. 4.1) is an interactive learning platform that currently focuses on teaching mathematics but will expand to include other subjects in the future. Studyly is now (April 2023) used by more than 30,000 students, with over 500 teachers integrating the platform into their lessons. With the help of Studyly, pupils can independently acquire knowledge on all relevant topics in mathematics. The learning platform saves the individual learning progress of each user, whereby work can be (continued) independent of location and device. For example, it is conceivable that a student begins learning or practicing on the computer, then continues working on the mobile phone, and finally uses the tablet. A multivariate Glicko algorithm constantly adapts to the users knowledge and performance, and ensures that the user is not over- or under-challenged. Based on the strengths and weaknesses of the student, the Glicko algorithm sets the appropriate tasks in a system that is constantly learning.

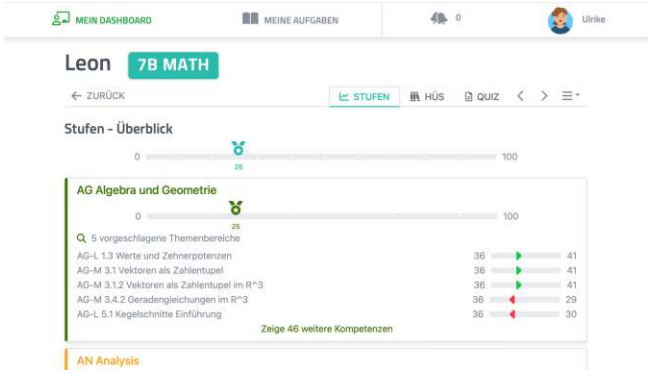
Furthermore, Studyly allows teachers to organize their classes by managing the respective students and their continuous learning progress. In addition to homework, quizzes can also be set for students to complete. The teacher can get an overview of a class's current performance level or individual students at any time, making very concrete personal support possible if necessary (see Fig. 4.2).

Figure 4.1: Entry page of Studyly [Fri]

While solving tasks, pupils are constantly motivated and encouraged through gamification not only to work on tasks set by the teacher but also to deal with mathematics independently. For each correctly solved example, students receive flames or even virtual clothing items to customize their avatars. If an example is solved incorrectly or not at all, there is no harsh criticism; instead, step-by-step explanations help them see through the solution [Mau22] (see Fig. 4.3). Furthermore, Studyly offers teachers a schoolwork and worksheet generator, which allows the individual compilation of schoolwork and worksheets in an attractive layout without much effort.

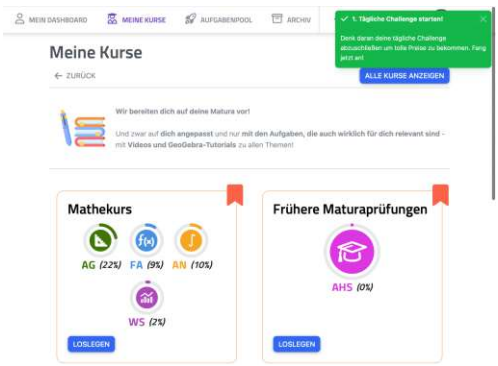


(a) Giving up a new homework assignment [Fri]

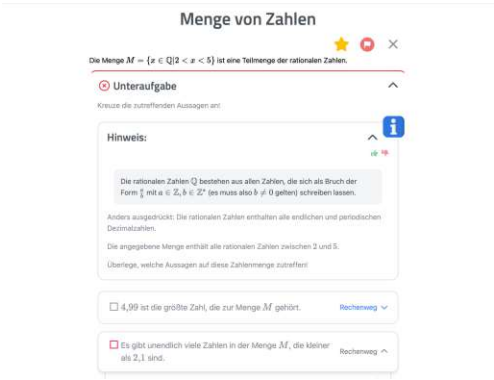


(b) Display of the strengths and weaknesses of a specific pupil [Fri]

Figure 4.2: Teacher's perspective for mathematics



(a) Course overview [Fri]



(b) Solving assignments in the course [Fri]

Figure 4.3: Pupil's perspective for mathematics

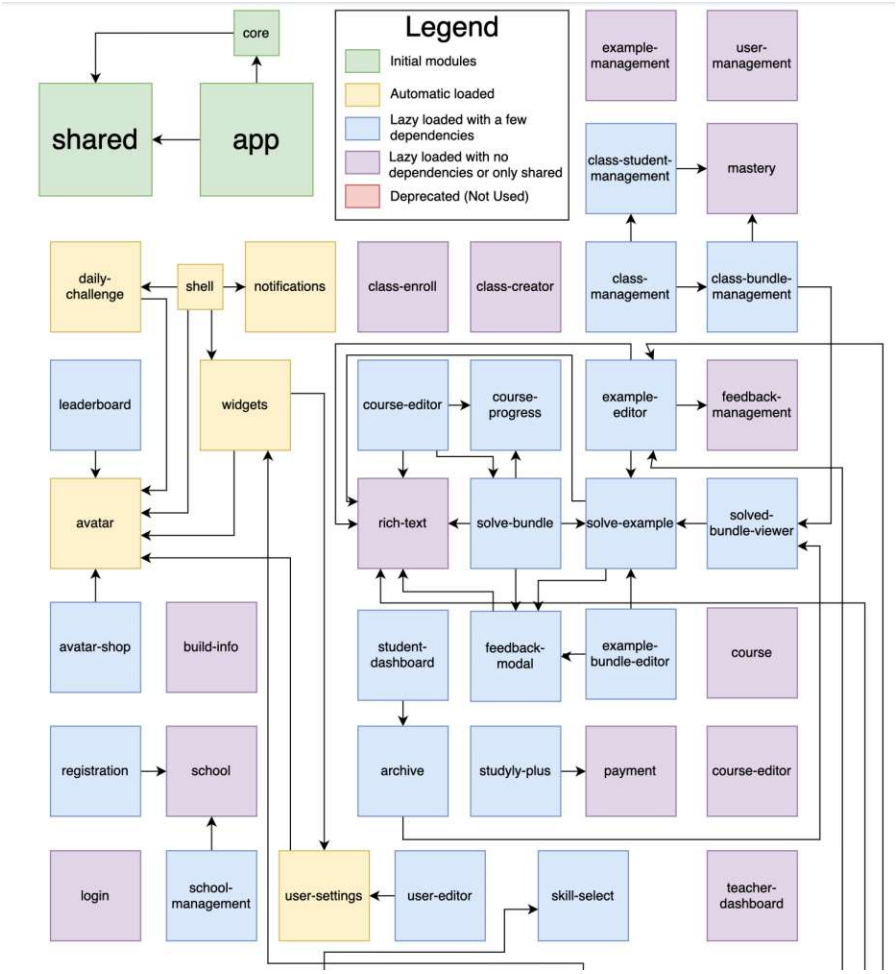


Figure 4.4: An extract from the module structure of Studyly [FSS] © Studyly GmbH.

4.2 Architecture of the Studyly platform

Studyly strives to maintain its technological edge by using state-of-the-art tools as well as technologies.

In particular, its frontend is built with Angular 13 and is composed out of a large number of modules, each with its own specific functionality. These modules are divided into two groups: those that are loaded initially and those that are lazily loaded when a student or teacher accesses a specific site.

For a visual representation of Studyly's architecture and loading mechanics, please refer to Fig. 4.4, which shows the different loading strategies in different colors. The module where the arrow originates imports the module where the arrow ends, indicating a dependency of the former on the latter.

The backend of Studyly is designed to be completely independent from the frontend and is built using Java Spring. To achieve this, Studyly has utilized a similar technology stack as the one covered in the TU Wien lecture "Advanced Software Engineering". This includes the use of a Postgresql database along with Redis. To capture the problem solvings of students, Studyly relies on MongoDB, which also serves as the foundation for the ML algorithm, which is written in Python using Tensorflow.

For authentication and authorization, Spring Security is used, supporting protocols such as oauth2 or openid connect. This is accomplished through the exchange of relevant JWT tokens, ensuring a secure and reliable user authentication experience.

Angular, Java Spring (Spring Boot), and Hibernate are a highly efficient combination that offers a scalable full-stack web development solution. Advantages of Angular are e.g. the active community and the large amount of online resources as well as the possibility of building complex website structures. This is necessary for teachers e.g. when giving a homework. With Angular it is namely ensured that the data is always at synchronisation at all levels.

Java Spring (Spring Boot) simplifies back-end development, and it is widely recognized as the standard for larger applications, which is why it is being included in the SEPM course at the Technical University of Vienna. Additionally, Hibernate provides reliable and efficient data persistence, allowing developers to focus on business logic rather than infrastructure. During the development process of Studyly, we have valued the flexibility of this technology stack and the large available documentation.

4.3 Perception of Studyly

In addition to the Austrian "Learning Apps" seal of quality, Studyly also received the "Comenius-Edumedia" award. The so-called "Learning Apps" seal of approval is a quality certificate awarded by the Federal Ministry of Education, Science and Research for digital mobile learning applications "[...] that have undergone a standardized evaluation and certification procedure" [fBWuF21b]. In addition to the fulfillment of defined quality criteria, a positive evaluation by teachers according to pedagogical, functional, and student-oriented aspects is required. As a certified platform, the user is entitled to use the corresponding quality seal and to display and describe it on the quality seal website. Certified apps can be purchased as teaching aids of one's own choice (UeW). The quality label is intended to offer teachers, pupils and guardians support, orientation, and assistance in selecting innovative quality products that are already established on the market. [fBWuF21b]

The so-called Comenius EduMedia Awards are honorary prizes which are not linked to a financial contribution for the award-winning institutions. They have been awarded since 1995 by the Gesellschaft für Pädagogik, Information und Medien e.V. (GPI), a scientific professional association for multimedia, educational technology, and media didactics. In its fourth decade of activity, the GPI promotes "[...] above all didactic multimedia

products that are outstanding in terms of pedagogy, content, and design". [OM15] The "Comenius Seal" and "Comenius Medal" are awarded annually for didactic multimedia products. In the category of special prices, Studyly was awarded the Corona Special Prize in 2020. The awards are given for "[...] outstanding ICT-based educational media from all educational areas, fields of application and educational content areas, which are available as CD-ROM, as DVD or on the net or as a hybrid offer, as an authoring system, as a network or as a platform for educational purposes" [OM15].

4.4 Comparing different learning platforms

To engage in a meaningful discussion about which product is best suited for teaching Informatics, it is necessary to analyze the relevant current offerings.

There are lots of digital learning platforms available, but only a few of them offer comprehensive and appropriate content or necessary features for Informatics instruction. This is likely because Informatics is currently only taught at the fifth grade of the AHS. However, with the recent introduction of "digital basic education" as a mandatory subject in lower grades, it can be expected that there will be an expansion in the range of offerings for Informatics education in the near future.

Therefore, it makes sense at this point to present and discuss the basic didactic concept of the individual learning platforms rather than the content. In the first step, a decision about which platforms can be considered for the necessary comparison will be made, since not all applications offer the essential functions for target-oriented use.

In addition to numerical evaluations, a platform for teaching Informatics must have a structured course system to allow for meaningful and effective use during lessons. It is equally important for teachers to have access to student performance data, so they can track their progress and assess their status quo at any time.

For this reason, all platforms that focus on foreign languages, such as "Duolingo" or "Learnmatch", are excluded from this comparison. Likewise, it does not seem to make sense to consider offerings for languages that are no longer spoken, such as "Navigium" for Latin. Thus, only platforms that have been developed for the ICT sector are suitable for this discussion. Therefore, we will elaborate on the following six platforms:

- eSquirrel [Mau]: This learning app (see Fig. 4.5) is structured as a quiz format, where students must correctly answer a set number of questions to complete individual learning units. The app is designed to provide an additional source of motivation, and the courses are linked to various textbooks for further learning. Teachers have access to features that provide them with an overview of how their students are performing on specific tasks.
- SchuBu [WMUSP22]: This product (see Fig. 4.6) specializes in teaching the natural sciences and attempts to reproduce the most diverse elements of a textbook in a

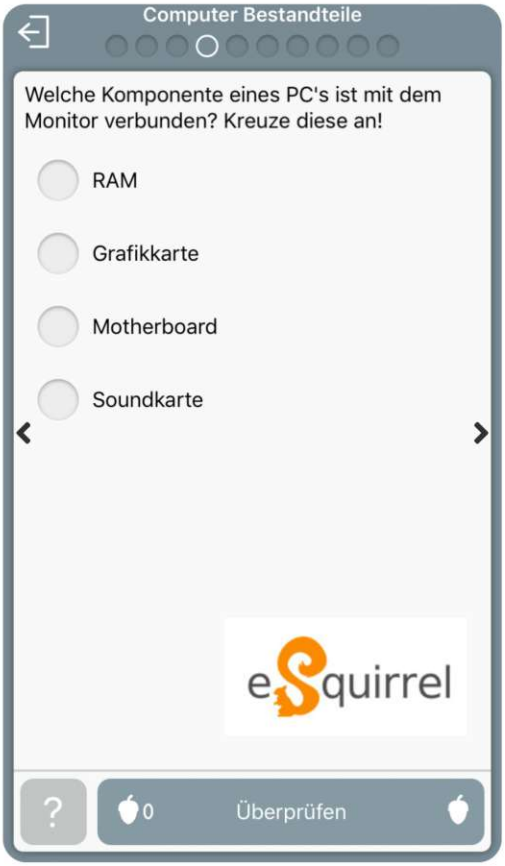


Figure 4.5: "Digitale Grundbildung" course by eSquirrel [Mau]

digital form. Tasks are solved via specially programmed elements per learning unit, which is why a specific design is required for each of these learning units in order to be suitable for the respective subject area. This makes the platform good for use in the classroom.

- MatheArena [Inf22]: This interactive application uses multiple-choice tasks to introduce students to various mathematics topics. Its focus lies on the individual support of pupils and is not necessarily suitable for making the corresponding learning results transparent for teachers.

- Mathe Trainer [GB]: This web application was developed as a digital add-on product for "Genial! Mathematik" to expand this textbook's contents with interactive elements. This application, which is mainly used in secondary schools, is offered together with the printed textbook.

- Moodle [Ltd]: Although Moodle is not an application comparable to the platforms described here, Moodle offers the appropriate framework for a sensible solution for

Figure 4.6: Sample content of Schubu [WMUSP22]

cooperation with a wide range of schools. However, there is no generally usable content on this platform, which is why Moodle may well be suitable for individual institutions.

- Studyly: As explained before, it is an interactive educational app that digitized various teaching scenarios with a focus on mathematics. It allows for inputting complex equations, Greek letters, and superscripts/subscripts, and can understand and process mathematical formula sets. Unlike other platforms, Studyly does not limit students to predefined notations and can accept answers with varying degrees of precision. This makes it a unique offering among educational apps, as it allows for learning and practicing through homework and actual lessons (including repetition, school work generation, and structured course system). This approach covers essential aspects of traditional classroom settings, such as understanding, problem-solving, transfer, reflection, and independent discovery.

4.5 Why Studyly was chosen

In the following, the decision of why Studyly is best suited for piloting in the context of Informatics teaching will be argued.

It is clear that topics such as "Encryption", "Basic Programming (Logic)" and "Artificial Intelligence" are highly mathematical in nature, and therefore mathematical input has to be understood. For instance, the ability to input equations is necessary for the "Encryption" chapter. Studyly offers this capability, making it a suitable platform for teaching such "mathematical" topics in the field of Informatics.

In addition, it is required to implement a course structure, so to speak, which is reflected not only in tasks but also in video explanations and text elements. Interactive elements must be integrated with the text elements to provide a comprehensive learning experience. Teachers must also have the ability to monitor their students' progress and provide individualized support as needed.

Gamification elements also provide enormous additional motivation for the students, as seen earlier in this paper. Studyly tries not only to implement individual isolated aspects of gamification but it also offers a wide variety of gamification elements for different types of learners.

Organizational features such as class management, electronic class registers etc. (see table 4.1 and *) are covered on Moodle and (deliberately) not on Studyly. Studyly integrates with Moodle (or Microsoft Teams), so that Studyly may be used in combination with an organizational platform. For (**), language aspects are currently not covered with Studyly. For such application cases, e.g. another platform has to be chosen.

Table 4.1 shall summarize the above arguments by comparing all the different aspects.

The author's experience and involvement in the development of Studyly since its inception provides a deep understanding of the platform's structure and strengthens the decision to expand its use to Informatics. Along with the content and technical arguments (see above table), this experience adds further justification for the selection of Studyly as platform of choice.

Feature	Studyly	Other platforms
Adaptive algorithm that adapts to the strenths and weaknesses of the students. Not every student gets the same problems but targeted to his / her needs.	x	
Possibility to enter mathematical expressions and not just text.	x	
Representation of a course structure	x	eSquirrel, MatheArena, Moodle
Gamification	x	eSquirrel, SchuBu, MatheArena
Possibility to connect with MS Teams	x	Moodle
Teacher can see student's process	x	eSquirrel, Moodle, MatheTrainer, SchuBu
Student's process on competence level (like in the curriculum)	x	
Organizational features such as class management, electronic class registers etc. (*)		Moodle
Support for language heavy question types (**)		eSquirrel, SchuBu, Moodle

Table 4.1: Key arguments why Studyly has been chosen

CHAPTER 5

Implementation strategy on Studyly

Having covered the relevant topics and examined the requirements for digital learning platforms in the previous chapters, the next step is to find out how to implement this in the best possible way through innovative and new technologies. As the decision was made to use Studyly, all its functionalities and pre-defined features will be taken into account when integrating the learning content.

5.1 What should Studyly offer for Informatics teaching in general?

In many conversations with teachers, it was found out that the use of Studyly for mathematics focuses in particular on homework, the improvement of already acquired mathematical knowledge, voluntary practice, and schoolwork and final exam preparation ("österreichische Zentralmatura"). In contrast, the platform is not used as often for the preparation of novel topics or as part of school activities. Likewise, it is mainly the automatic correction of homework that is appreciated.

Furthermore, the study results of KPH-Wien/Krems [Gab] confirm that giving assignments (to pupils) and the overall overview of a group's performance is of elementary importance for using Studyly in mathematics. However, a completely different picture emerges for Informatics: Based on several discussions with Informatics teachers and empirical values from other relevant platforms (SchuBu, Inf-Schule [Bec],...), the focus is on the use during lesson time. This must be considered in the implementation strategy that follows.

5.2 Presentation of the five topics

In this chapter, we will discuss the subject areas that are included in the Informatics syllabus for the fifth grade of AHS. It is important to map this content on Studyly accordingly. In this respect, five subject areas will now be further examined.

5.2.1 Cryptography

In the first step, the students are asked to approach the topic of cryptography independently based on a text by the internationally renowned expert on IT security Bruce Schneier [Sch15]. Secondly, students are asked to excerpt the most important statements of this input text and discuss them in class. After this introduction, the corresponding theoretical explanations follow: In addition to explaining that cryptography describes the science of encrypting (enciphering) and decrypting (deciphering) data using a secret piece of information (the key), the aim of cryptography, namely to decipher encrypted data without knowing the private key, is explained. Subsequently, the students will be taught why cryptography is considered elementary for the safe use of computer systems. Finally, the goals of cryptography - namely confidentiality as well as message and data authenticity - are described. [Buc10]

After this introduction to the subject, we now shift to the background of actual encryption procedures. For this purpose, the historical Caesar encryption procedure processes must be made easily understandable. Although this application is no longer a modern procedure, its relative simplicity makes it ideal for understanding this subject.

Since the Caesar encryption method is based on a relatively simple principle, it is not considered secure. After all, it is conceivable with minimal effort to try out all possible keys and thus determine the actual meaning of a ciphertext. Making this clear to the pupils and further discuss how this procedure can be made more secure is a crucial step during class.

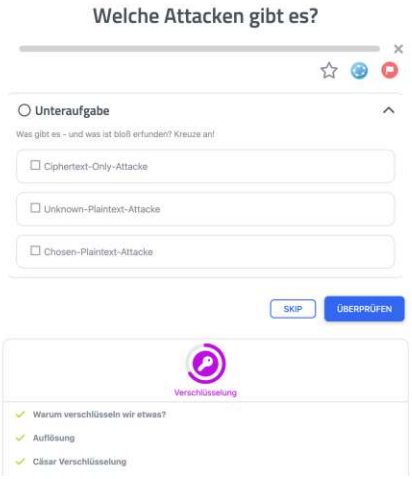
Finally, an explanatory video from the well-known YouTube channel "Kurzgesagt" refers to the problems of quantum computers in terms of loss of security, which arise due to their different structure.

See for example in Fig. 5.1 a reference implementation of this topic.

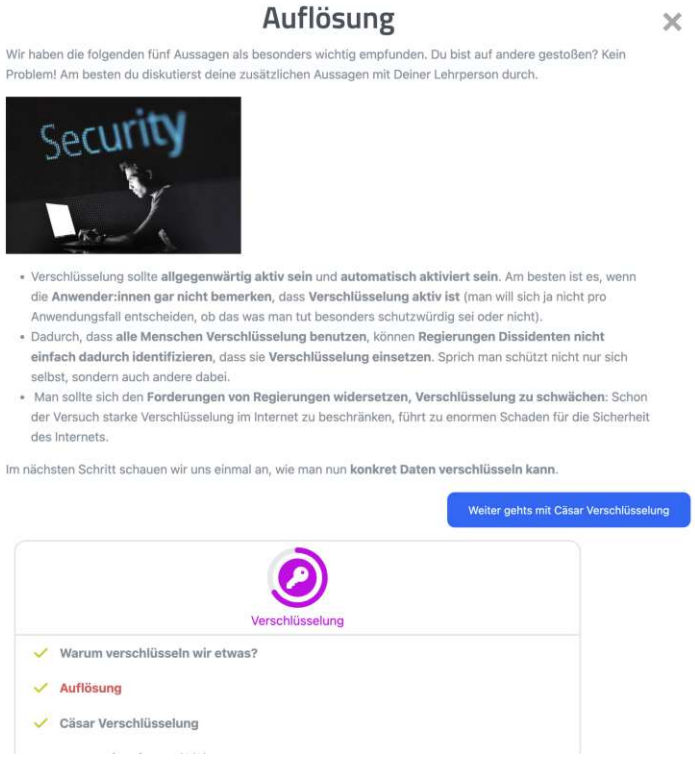
5.2.2 Data security and law

Now we will look at how the area of data security and law could be implemented (as a central aspect of Informatics teaching) at Studyly. The following explanations are based on a scientific contribution by Roland Gimmler, an expert in media education [Gim12, p. 110-116]. In principle, the focus should be on showing the effects of using different media platforms can have concerning data protection and law. Students will be introduced to this topic by presenting different Facebook profiles, some of which show certain deficiencies in data security. A comparison of these profiles will show the

(a) Information technology course [Fri]



(b) Different forms of attacks [Fri]



(c) Security article [Fri]

Figure 5.1: How pupils see e.g. the topic of cryptography on Studyly

dangers that can result from the careless handling of personal data. In the next step, the discussion will be extended to other social media platforms to assess terms of use in data protection. The aim is to sensitize the students to what needs to be considered when personal data is disclosed on the Internet. With this approach, the areas of evaluation knowledge, judgment competence, as well as reception and processing competence can be encouraged ("prozedurales Wissen und die Auswahl- und Nutzungskompetenz") [SG07, p. 271-296].

The dimensions of procedural knowledge and selection and utilization competence should not be neglected either: This is why the pupils are then given the task of getting to know the different functions of the social networks they use (e.g., Tiktok) and practically experience changes regarding the visibility of information. Finally, the students will be given a research task to explain the different content licenses (such as for images). The main focus will be on Creative Commons licenses. This will allow students to understand what content they can use on the Internet without acting illegally and breaking the law.

5.2.3 Artificial Intelligence

Next, we will outline how the field of artificial intelligence (AI) can be meaningfully represented in the classroom.

To provide an exciting first introduction to this topic for the students, we will highlight the recent developments in the machine learning, particularly ChatGPT [RWC+19] . To give students a practical experience with this technology, we will ask them to create a multiple-choice quiz using ChatGPT on a self-selected topic and then have them share and ask these questions to their neighbours. Through this activity, students will better understand ChatGPT's capabilities and limitations.

For the practical part, we will look at a classification model, which is often seen as one of the most basic elements in the field of machine learning. Here we are taking [SCF21, p. 79] as a reference. In this respect, such a model is to be developed with which black-and-white pictures of traffic lights can be correctly classified as green or red. For this purpose, the students will be explained what an SVM (Support Vector Machine) is and how it can be used to separate data linearly, using a video as an illustration. Subsequently, the knowledge acquired on a theoretical level is to be applied practically to the traffic light problem. Since the pupils are only in the fifth grade and, thus in the Austrian school system, have only mastered vector calculus in 2D unlike in Schönbrodt et al., emphasis in discussion is placed on referring only to the essential mathematical background. For interested pupils, there will be an excursus explaining the underlying formulas. [SCF21, Schönbrodt (2019) & Schmidt (2020) as cited in p. 79]

5.2.4 Basics of Programming

Furthermore, a short introduction to programming will also be offered on Studyly. For this, it is based on the work "Programmieren mit Kara. Ein spielerischer Zugang zur Informatik" [RNH06] by Raimond Reichert, Jürg Nievergelt and Werner Hartmann. The

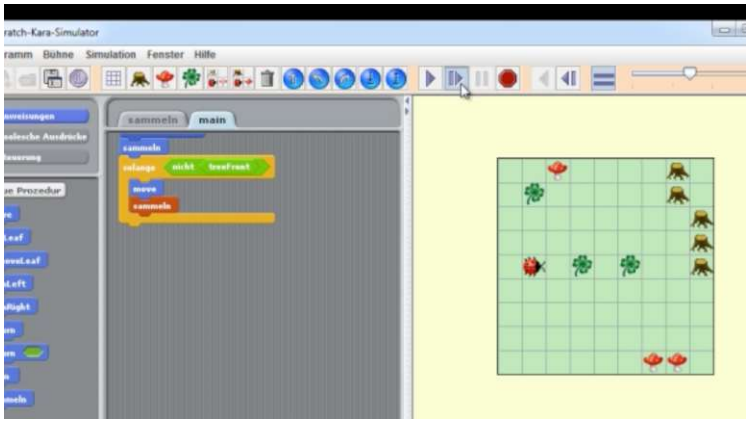


Figure 5.2: Interface of ScratchKara [Bol]

two authors being renowned computer scientists, provide a proper understanding of the programming background playfully. This is done "free from the shackles of professional development environments". [Rei], building upon this book, provides practical guidance is given to teachers on how Kara can be usefully and easily integrated into the classroom: Thus, Kara (ladybird) is programmed in a graphical development environment, which lives in a screen world. Different programs are linked together, leading to specific movements of the beetle. On the other hand, the respective program is presented to the student as an automaton. On Studyly, sample requirements for the movement of the ladybird are given, which pupils must fulfill independently. After the actual programming, the correct procedure is illustrated.

Since it was challenging to install the original Kara software during a test attempt directly during the lesson, ScratchKara [Bol] is used, a new version of Kara in combination with Scratch (see also Fig. 5.2). Finally, using ScratchKara will demonstrate these automata's importance for everyday life. As with Reichert, reference is made to the example of the ATM [Rei].

5.2.5 Vector and Raster Graphics

For the area of vector and raster graphics, reference is made to the explanations of Peter Hubwieser, who describes concepts in "Didaktik der Informatik" on how teaching modern learning content can succeed in school [Hub07, p. 138-146]. In the first step, texts and illustrations are used to explain the differences between the representation of a vector graphic and a raster graphic. For example, in the case of a vector graphic, the generalization concept of classes is pointed out. However, in the case of a raster graphic, the content of an illustration does not play a role as the information is prepared utilizing pixels. In addition, the general concept of raster graphics is discussed. For example, the student is asked to calculate how many elements the sequence of a given image as if it has x-rows and y-columns. In addition, the question of how to find an existing pixel

within the sequence is also addressed. In this context, the memory used per number of color levels is discussed further.

Afterwards students are asked to argue why, in the case of vector graphics, the respective graphics are relatively smaller in terms of file size than raster graphics. Hence, students are able to download both documents (raster as well as vector graphics) in order to determine which information in a vector graphic requires storage space in addition to the respective elements (image size, background, etc.). The learning outcome is to understand whether converting a raster graphic to a vector graphic or vice versa is more complicated. After a debate in class, a video is used to clarify this question.

According to Hubwieser, the students should now be able to consider the various advantages and numerous disadvantages that vector graphics entail. Hence, a table provides an overview of the advantages and disadvantages of these two types of representation. According to Hubwieser, the benefits of raster graphics are good reusability, no need for an analytical description of the shapes, and relatively simple processing algorithms, whereas the disadvantage is high memory consumption. Regarding vector graphics, low memory consumption and a relatively simple realization of geometric operations with the objects and the complexity of recognition algorithms need to be considered.

5.3 How is the curriculum represented in Studyly?

The ideas outlined in the previous chapter have now been implemented interactively on Studyly. In order to achieve this, an interactive editor (see Fig. 5.3) was used offering different task formats (each with varying learning objectives). This allows the course editor to depict not only multiple-choice, drag-and-drop, and open formats, but also link these tasks with text and video elements. By entering data in the various fields, Studyly independently assembles them in the best way possible ensuring a constant adaptation to the concrete task format. Attention must be paid to the correct choice of the respective task format in order not to counteract the learning effect.

According to Regina Bruder and Julia Sonnberger [BS08, p.228-238], it is crucial to analyze which type of question is used to ensure the best possible learning success for the students. In this context, deciding which task formats are best suited for the respective areas in the subject matter is crucial to make competencies visible. As each of these formats has specific characteristics that lend themselves to the explicit learning content. In this respect, reference should be made to a study by Regina Bruder that presents eight different formats for working with questions in the context of e-learning. According to her conclusion, these approaches can decisively support sustainable learning if implemented in an adequate subject-specific manner. In the following, these different types of tasks are presented in a tabular form and then how they are applied to Studyly for Informatics.

As illustrated, it was essential for Studyly to initially start with an explanatory treatment of a corresponding task. At least a certain degree of interactivity is required from the students. For example, a task text must be read, and subsequent explanations shall be

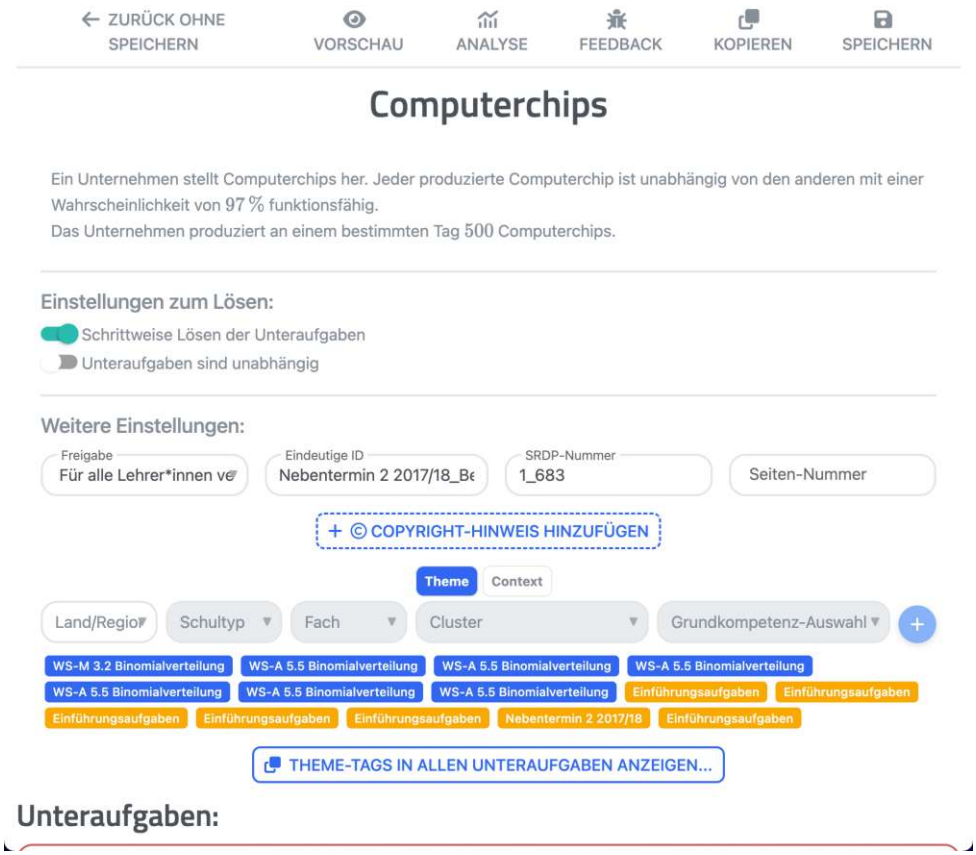


Figure 5.3: Editor to implement interactive tasks [Fri]

received - step by step. The second step is to apply the previously acquired knowledge to the framework of relatively simple decision-making processes (e.g., in joint discussions with the teacher). Furthermore, it should also be possible to solve more complicated tasks (such as reversal tasks, determination tasks, or complex open questions). Depending on the type of task, the corresponding structure types are used in different numbers or to various degrees. The ultimate goal, regardless of the subject taught - of Studyly is to boost the motivation of students and allow them to reflect on the topics covered. In summary, the focus should not just be on the variety of tasks but rather on the adoption or change of perspective on particular learning content. [BS08, p.228-238]

For the current project, this means that behaviorist learning should be regarded as a central component. The importance of such an approach manifests itself primarily in the fact that learning takes place based on events in the environment and that it is precisely this self-exploring learning that results in increased motivation to learn. [UDF19]

Now that the basic concept concerning the preparation of the questions has been outlined, the guidelines concerning their formulation should be dealt within concrete terms.

Gegebenes	Transformationen	Gesuchtes	
X	X	X	gelöste Aufgabe, ein Erklärungsmuster oder Beispiel
X	X	–	einfache Bestimmungsaufgabe, es ist eine bekannte Handlungsanweisung nur noch auszuführen
–	X	X	einfache Umkehraufgabe, die Eingangsvoraussetzungen für ein mit bekannten Vorgehensweisen erzieltes Resultat sind gefragt
X	–	X	Beweis- oder Begründungsaufgabe, eine Argumentationskette ist gefragt oder eine Strategie ist gesucht, z.B. auch eine Spielstrategie
X	–	–	schwere Bestimmungsaufgabe; ggf. müssen die zur Lösung geeigneten Wissenselemente erst erarbeitet werden
–	–	X	schwierige Umkehraufgabe
–	X	–	Aufforderung, eine Aufgabe zu einem Wissensgebiet selbst zu erfinden
(–)	–	(–)	offene Problemsituation, Projekt, eine Modellbildung

Figure 5.4: Classification of tasks according to knowledge of their structural elements [BS08, p.233]

5.4 Guidelines influencing the creation of questions

The following section is based on the internal guidelines for creating mathematical tasks on Studyly, but adapted where necessary to make it fit for Informatics.

5.4.1 Form of address

Undeniably, it is not so straightforward to answer the question of whether the addressees (in this case, the students) should be addressed "per Du" or as "per Sie". After long and intensive considerations, it was decided neither for one nor for the other, but the following compromise was reached: As far as possible, "you" formulations should be avoided since Studyly acts as a mediator of knowledge and therefore wants to maintain a certain amount of distance or respect for the learners. Instead, direct ("Please remember that the example is not over yet!") or general instructions such as "Before getting the solution, running the algorithm from back to front is necessary!" should be used. In addition, a sense of togetherness should be created with "we-formulations".

5.4.2 Style and sentence structure

The principle in this context should be the following: "As simple as possible, but not simpler!" According to this maxim, clear sentence structure should facilitate comprehension to the extent that the question can be understood as simply as possible without distorting the - sometimes complex - facts. The sentences should be complete, grammatically and semantically correct. If possible, complicated expressions should be avoided. Likewise, long and "convoluted" sentence structure, paraphrases ("sentence inserts") or vague references in brackets should not be used. Since the meaning is to be inferred from the respective formulations alone, block letters and bold or italic typeface are not used. It must not lapse too much into collegial Informatics tutoring jargon. Communication should be conducted on a professional level. Finally, it is essential that the level of knowledge of pupils who show difficulties in this subject is also taken into account and that the explanations only take place at a university level.

5.4.3 Information and notes

As with the information on the respective examples, the so-called and much-cited competence-oriented teaching should also be considered in the explanations of the individual solution steps. Regarding instructions to the pupils, each work assignment should begin with an understandable verb and end with an exclamation mark. This concept is also known from other areas, hence we speak of operators in this context. In addition to knowing what needs to be done, it is also possible to check whether all (sub-)areas of an example have been worked on.

5.4.4 Mathematical expressions

Formulas, as well as information technology expressions, should always be written in formula mode (Latex). If, for example, other programs have to be used to arrive at a solution, the same style should also be used for these expressions.

5.4.5 Duty of care

Within a specific framework, pupil statements can still be tolerable, even if a specialist judges them as inaccurate. Thus, statements are divided into groups: No-Gos, Grey Zone, and Green Zone. The no-gos are wrong statements that can be falsified in Informatics lessons. For example, the terms Internet and World Wide Web should not be used synonymously, even if this is often done in colloquial language. However, due to better illustration and their often more straightforward (and nevertheless correct) explanation, there are also situations in which complete exactness may be dispensed with grey area. Nevertheless, an attempt should always be made to pursue such a strategy only when it is proportionate. Ergo, mainly the green zone should be preferred. Suppose an exact justification for a statement should go beyond the subject matter of the school lessons. In that case, abbreviated or simplified explanatory approaches will be used so that the

☑	⚙	⊘
Die Wurzel aus jeder natürlichen Zahl, die keine Quadratzahl ist, ist irrational.		Wurzeln kann man nur aus positiven Zahlen ziehen.
Weil ihre Ableitung überall größer ist, muss die Funktion streng monoton steigend sein.	Bei einer Extremstelle ändert sich das Monotonieverhalten der Funktion.	Die Funktion ist streng monoton steigend, also muss die Ableitung positiv sein.
Weil n eine natürliche Zahl ist, muss auch $n + 3$ eine natürliche Zahl sein.		Wenn Pi dabeisteht, ist es immer eine irrationale Zahl.
	Der Graph der Polynomfunktion verläuft S-förmig, also ist es eine Funktion 3. Grades.	Das bestimmte Integral ergibt die Fläche.
Alle Zahlen liegen zwischen 0 und 10, daher kann die Standardabweichung nicht 20 sein.	Die Standardabweichung ist die mittlere Abweichung vom arithmetischen Mittel.	Der Median steht in der Mitte der Liste.
	Zwei Stammfunktionen einer Funktion unterscheiden sich immer um eine Konstante.	Konstanten fallen beim Ableiten weg.
Der Erwartungswert gibt an, welchen Wert die Zufallsvariable bei oftmaligem Wiederholen des Zufallsversuchs im Durchschnitt annimmt.		Der Erwartungswert gibt an, welchen Wert man erwarten kann.
Das lineare Gleichungssystem besitzt unendlich viele Lösungen, weil die Gleichungen linear abhängig sind.	Das lineare Gleichungssystem besitzt unendlich viele Lösungen, wenn die Gleichungen Vielfache voneinander sind.	Eine diskrete Zufallsvariable hat endlich viele; eine stetige Zufallsvariable hat unendlich viele verschiedene Werte.
Es gilt: $lim_{x \to \pm\infty} f(x) = 0$ Also ist die x-Achse eine Asymptote der gegebenen Funktion.	Der Funktionsgraph nähert sich der x-Achse beliebig an, ohne diese zu schneiden. Also ist die x-Achse eine Asymptote der	In jedem der 4 Abschnitte eines Kastenschaubilds (Boxplot) liegen genau 25 % der Werte.

Figure 5.5: In mathematics these are our "No-Gos, Grey Zone, and Green Zone"

understanding on the part of the students is also maintained. See also Fig. 5.5 for the concrete "No-Gos" or desired formulations for mathematics.

5.4.6 Graphics

Although graphics are helpful for illustrating solutions to problems, they should only be used if an argumentation is provided. A fact, which should not be underestimated, is that visual representations (graphics, images, tables) from the World Wide Web are subject to copyright and are, therefore, strictly protected. Hence, they may not be used without express permission and it is important to be careful when using or integrating graphics to get the necessary licenses. Finally, those responsible for creating lesson plans should ensure that the visual representations used are not blurred or "pixelated" in any way.

5.4.7 Gender-sensitive language

In the 21st century, it has become standard to consider all genders in language, hence promoting awareness of equality. Conscious use of language - as illustrated with examples in the following guide - can remedy an imbalance to this effect. In scientific and everyday texts, some people consider the use of gender-equitable language is perceived as difficult to read or incomprehensible [fBWuF]. In the meantime, there are several ways to represent equality between women and men in language. After intensive consideration, the guidelines currently in force at the Vienna University of Technology were chosen, which suggest gender-neutral language by using the underline [Str].

CHAPTER 6

Use of Studyly in actual teaching

The initial, theory-related examination of the topic should have contributed to a sensitization concerning the information technology taught in class. This preliminary understanding, which is already expressed in the research questions stated at the beginning of this thesis, will be expanded and refined in the context of this chapter and corrected, if necessary.

- Q1: What content is needed in terms of a concrete implementation strategy as well as a subsequent actual implementation?
- Q2: How should the interactive tasks on Studyly be designed to maximize student learning of Informatics as a school subject?
- Q3: After the pilot application has been completed, what strengths and weaknesses can be derived for further development steps?

These three questions could be partially answered by the scientific discussions that have taken place so far in the context of this master's thesis:

- The implementation strategy (Q1) for Studyly's use in teaching Informatics in schools was developed based on relevant literature, such as works by Hubwieser, Buchmann, and Gimmler. A didactic concept for delivering the necessary content on the platform was created using these sources (five topic areas).

  In this context, it became apparent that areas such as interactivity, variety in the preparation of the tasks, or concrete instructions for action are positively impacting student motivation.

Figure 6.1: Different levels of the degree of digitalization [ReA]

- The second question (Q2) complements the first and provides crucial insights from the theory (e.g. Bruder and Sonnberger). The way tasks are presented on Studyly must be adapted to the specific content. For instance, in cryptography, students need hands-on experience to understand the material and benefit from it. In chapters like data security and law, the emphasis should be on collaboration and discussion between teachers and students, with opportunities for reflection.

- This thesis third and final question ("After the pilot application has been completed, what strengths and weaknesses can be derived for further development steps?") requires a discussion of the empirical results generated in a qualitative survey.

6.1 Choice of the specific schools

The practical implementation of the topics discussed in previous chapters will now be demonstrated through exemplary teaching units. The author reached out to teachers who specialize in digitalization, taking into account school quality features, such as the "MINT Quality Seal" or "eEducation Expert School" label, and their expressed interest.

6.1.1 eEducation Expert Schools

"eEducation Expert Schools" are schools that consciously recognize the importance of e-Learning in their teaching and also try to further enrich their teaching with "meaningful use (in a wide variety of subjects)". These schools are members of the "eEducation Austria Network", in which there are three levels - depending on the degree of digitalization - "Member School", "Expert School" and "Expert+ School" (see also Fig. 6.1). Additional further training opportunities such as 'School-internal teacher training' (SCHILF) or 'School-wide teacher training' (SCHÜLF), which are explicitly provided for the respective teachers, contribute to this concept. These schools are actively supported in further developing their school concept and networked with other schools (e.g., with a higher status). This creates the opportunity for schools to learn and benefit from each other, which can be highly beneficial to both sides [ReA].

6.1.2 MINT seal of approval

Another possible award is the so-called MINT seal of approval: This is awarded to schools that try to implement innovative learning in mathematics, information technology, natural sciences, and technology through various measures. For example, "application-oriented, practical and research-based learning" is to be promoted, or STEM education paths shall be actively communicated [HW].

6.1.3 Procedure

Since these schools - to obtain or confirm their respective seals - have to prove related activities every year, it is reasonable to argue that these schools have a particular interest in playing an active role in the piloting of Studyly for Informatics.

In this context, the author of this paper tried to get in touch with corresponding "eEducation Expert schools" or "eEducation Expert+ schools" or MINT seal of approval. At the same time it was crucial to also inform them about the organizational challenges - such as filling out forms - that the respective schools would have to overcome (e.g., quantitative questionnaires from pupils and qualitative feedback from teachers).

Additionally, the author of this thesis leveraged the existing use of Studyly in mathematics to make it easier to find relevant schools.

In conclusion, the selection of schools (in total five) for the qualitative survey was made with care, to not over-represent specific criteria:

- Corresponding urban/rural disparity: At most, two general secondary school or "AHS" in German from Vienna should be included in this project. In the future we will use the term "AHS" to describe this school type.
- Private versus public: At most, two AHS should be privately run.
- IT affinity: At least three secondary schools should have either a MINT seal of approval or an eEducation Expert seal.

So in this way, an effort was made to accurately depict the target field of application for Studyly in Informatics with a focus on realism (when it would be actually used in class situations).

6.2 Initiation of the survey

After having selected the five schools (see Table 6.1) which agreed to participate (via this around a hundred pupils use Studyly in their classrooms), the start of the pilot phase could begin.

Description of the school	Urban / Rural	IT affinity	Private / Public
T1: School in the surroundings of Klagenfurt	Urban	Expert School	public
T2: School in the surroundings of Oberwart (Burgenland); focus on music as a school subject	Rural	MINT quality seal	private
T3: School (BORG) in the north of Carinthia ("Kärnten"); optional focus on " information and communication technology"	Rural	Expert School	public
T4: Private school in Vienna with a focus on languages.	Urban	Expert School	private
T5: Primary school with specific talent development programs.	Urban	Expert School	public

Table 6.1: Chosen schools for the pilot application

It is worth mentioning that these four teachers also taught mathematics in addition to Informatics and were already familiar with Studyly. After a concept presentation, these Informatics teachers were asked to share their lesson plans, which would subsequently find their way onto the Studyly platform. In addition to the four secondary schools, a primary school (T5) came towards the author, who intended to use the platform in terms of their talent development classes ("Begabungsförderungsstunden"). This is why, the author has visited those classes to gain additional insights how the platform could be used by primary pupils. Those results are not included in the quantitative studies with students, but in the second qualitative studies.

By mid-December 2022, the concept was ready, and the focus on Informatics as a subject area was highly appreciated.

6.3 Start of the pilot phase

After the didactic conception and presentation were completed, the study was initiated. During this interview, the subject areas and their implementation were discussed in detail (see questions IQ4 and IQ5). Emphasis was placed on communicating the didactic benefits and the significance of incorporating Studyly in the classroom.

To ensure success, it was essential to provide the best possible support to those participating in the pilot project, allowing them to fully utilize and benefit from Studyly.

Taking into account the advantages of a semi-structured survey, qualitative guided interviews, specifically expert interviews, were conducted.

In the present survey, it is crucial to allow the interviewees to answer the questions posed and letting them speak freely, depending on their views on the different teaching scenarios. This enables one to get a deeper insight into the teachers' experiences, ideas, and needs in order to further develop an even more appropriate product. In connection with expert interviews as a particular form of guided interviews, the question arises as to who is considered an expert.

There are different opinions on this. The present study is based on a relatively open understanding: "The answer to the question of who or what 'experts' are varies greatly depending on the object of investigation and the related theoretical-analytical research approach. (...). Experts could be those persons who are particularly competent as 'experts' concerning an issue of interest" ([Dee95] and [Fli07])

The expert status of the interviewees for this survey results from the logical understanding that they are Informatics teachers and open to Studyly. As discussed previously, in all the cases, they already had experience with the platform in connection in the subject of mathematics. The interviews were conducted exclusively online due to better documentation and more straightforward transcription.

The duration of this piloting was to be one month, whereby assistance could be accessed at any time during this phase. At the same time, the amount of support needed should allow to draw conclusions about how user-friendly Studyly proves to be.

The German version of the interview guide can be found in the appendices. This text presents the main results from the qualitative studies, which were focused on encryption to ensure comparability. However, even if a teacher has never taught this subject area, they can still choose another as the focus of the didactic questions.

6.3.1 IQ1: Do you know Studyly and / or have you already used it for your lessons?

The question of whether Studyly was known was answered in the affirmative by all the teachers interviewed, who also stated that they had already used the platform (for mathematics). Therefore, it was not necessary to explain the learning platform in detail.

6.3.2 IQ2: Concerning the subject area of encryption: How do you teach this content in your lessons?

Four of the interviewees stated that Caesar encryption was the primary focus in their lesson design on encryption.

- T1 resorts to encryption trees within the lesson's framework to encrypt self-selected words using a self-selected key or to decrypt the words of fellow pupils.
- T2, on the other hand, stated that she had yet to deal with the topic of encryption in class but that she could imagine searching for corresponding worksheets on the Internet if necessary and preparing these materials for class.
- The third teacher interviewed (T3) relies on the teaching content provided by the University of Wuppertal on 'Matheprisma'. There, learning sections are supplied in the most diverse areas of Informatics (including encryption). She uses this learning path for RSA encryption.

  However, she also briefly discusses Caesar's encryption beforehand by presenting an encrypted love letter, provided with numerous emojis, to the students for decryption. According to her, the text she chose undoubtedly motivates her students to get involved in this topic.
- T4 teaches the basics of Caesar and Vigenère encryption by first explaining the decryption of the Enigma machine used by the Wehrmacht during World War II (which was accomplished by the Allies). This historical reference really interests the students (according to her) and is also used by T3 later in their lessons by showing a film about the Enigma machine.

6.3.3 IQ3: I would like to follow on from what you said: What forms of teaching do you expect from a digital platform so that you can integrate it meaningfully into the subject area of encryption, but also beyond that, in principle, in the classroom?

Regarding the expectations of a digital platform such as Studyly, as far as the preparation or teaching of the topic of encryption as such is concerned, T1 makes it clear right at the beginning that she does not rely on frontal teaching in Informatics lessons but instead on group work and joint development of the learning content. In addition, she does not give the pupils any assignments to take home. This means that Informatics lessons are designed differently and involve different challenges for the teacher than, for example, mathematics lessons. Concerning the question, she needs to get started in a particular subject area (such as encryption). According to her, when using digital learning platforms, the corresponding input options mustn't represent an additional hurdle for the pupils.

Likewise, clear explanations and supplementary materials for use in the classroom are essential to her. At the same time, she admits that she cannot (yet) imagine a concrete implementation of Studyly in Informatics teaching.

Furthermore, it was stated that they would like to use the learning platform 'LMS' in Informatics lessons to allow an individual learning pace and enable interactivity. The automated retrieval of learning content as well as the variety in theoretical or practical knowledge transfer, are in the foreground, which Studyly also desires. Finally, Studyly would have to do everything possible to avoid monotony in the classroom. Just as on 'LMS', it would be desirable if it were also possible to create one's content on Studyly (currently, the individual creation of tasks is possible here, but not of content, author's note). A combination of both worlds, i.e., the possibility to use prefabricated blocks for teaching but at the same time to adapt them according to one's own wishes, can thus be seen as an ideal.

The following survey (T3) clarified the lack of adequate textbooks for teaching Informatics in the fifth grade at AHS, which is why many resources are tied up in searching for suitable teaching material (on the Internet, for example). Due to this, the planned offer of Studyly will be welcomed as long as the Austrian curriculum is considered accordingly. Independent work and interactive multimedia elements are considered important.

T4's comments are mainly in line with the previous opinions, whereby this teacher strongly associates Informatics teaching with mathematics, which is why there should be the possibility of entering mathematical symbols. Finally, Studyly is expected to have an uncomplicated and logical structure.

6.3.4 IQ4: If you already have experience with other learning platforms of this kind: What is particularly important to you? In your opinion, what must such an offer be able to do in any case?

T2's prior experience with learning platforms emphasizes the need for simple and quick login, compatibility with various devices, and access to the teaching content for independent practice at all times, even without a specific homework assignment. In addition to ease of use, a clear interface is also considered important.

6.3.5 IQ5: May I now ask you to tell me what you think about the didactical concept of Studyly? What do you find good, and which areas do you see as critical?

Now that the relevant feedback has been obtained, the participants were guided in detail through the Studyly for Informatics. In this respect - in contrast to mathematics - the exclusive use in the classroom is of central importance. The teachers (especially those who already knew Studyly from mathematics) were quite surprised that it was possible to adapt such a platform and offer a corresponding course for Informatics lessons. T1 evaluated the structure and design of the course system as highly positive, with a particular emphasis on the introductory material covering topics such as encryption and data security and law. The explanatory videos provided by Studyly were also well received and deemed to be of high quality.

On the flip side, T1 criticized the limited scope of the encryption tasks, which only involve deciphering individual words, and would have preferred to see a more comprehensive context, similar to the lesson design in T3. Furthermore, there is a desire for the inclusion of more practical tasks, such as the "Caesar Cipher".

T2 evaluates the pedagogical and didactical concept positively, especially concerning teaching the subject area of encryption ("[...] I like it very much, yes!", T2). On the other hand, the desire to create their content is mentioned.

Two teachers, T3 and T4, had positive remarks about the way the various topics were introduced and the emphasis on self-study. They expressed that they could greatly benefit from using Studyly in their lessons. The fact that Studyly teaches programming using Kara is also appreciated. It was also noted in this context that the separate installation of the original version of Kara was complicated but that the connection of Kara and Scratch on Studyly was fine. Once again, the importance or the need for practical tasks was emphasized.

6.3.6 IQ6: Can you imagine using Studyly in your Informatics lessons?

All interviewees were open to the concrete use of Studyly in their Informatics lessons but, at the same time, stated that they wanted to wait a little longer for the (extensive) use of the digital learning platform, as this would require the completion of the previous topic. They suggested that it could potentially be utilized at the start of the next semester. Therefore the start of the pilot phase was set to the range of February 2023 until end of March 2023.

6.4 Pilot phase in classes

After a one-month pilot phase, a request for feedback was made from both teachers and students regarding the pedagogical value, usability, and motivation for using Studyly.

Both teachers and students will be surveyed, with the teachers being interviewed using a qualitative method (semi-structured expert interviews) and the students providing their feedback through standardized questionnaires.

6.4.1 Quantitative interview

In the following the results from the survey with the students are described. The complete questionnaire can be found in the appendix.

IQ1: Question regarding gender: I am...

The survey of students who used the platform during the piloting was conducted immediately after the end of the testing phase. Of the 105 students, 44 participated in this subsequent survey, with precisely half being female, just over 45 percent male, and 4.55 percent diverse. Although most respondents attended fifth-grade AHS at the time of the

survey, students who were enthusiastic about STEM subjects, regardless of grade level or age, were intentionally selected for the pilot. Only school T5 has been excluded from the qualitative survey.

IQ2: On a scale of 1 to 5, how much do you like the subject of Informatics? (Results see Fig. 6.2); IQ3: How much - on a scale of 1 to 5 - do you think Informatics is important for your future? (Results see Fig. 6.3)

The overall picture here is pleasing, with just over 84 percent liking Informatics lessons in principle. Only just under 16 percent are less or not at all enthusiastic about Informatics as such. Similarly, most respondents believe that Informatics is vital for their future. Only about eleven percent do not see the importance of Informatics for their later (professional) lives.

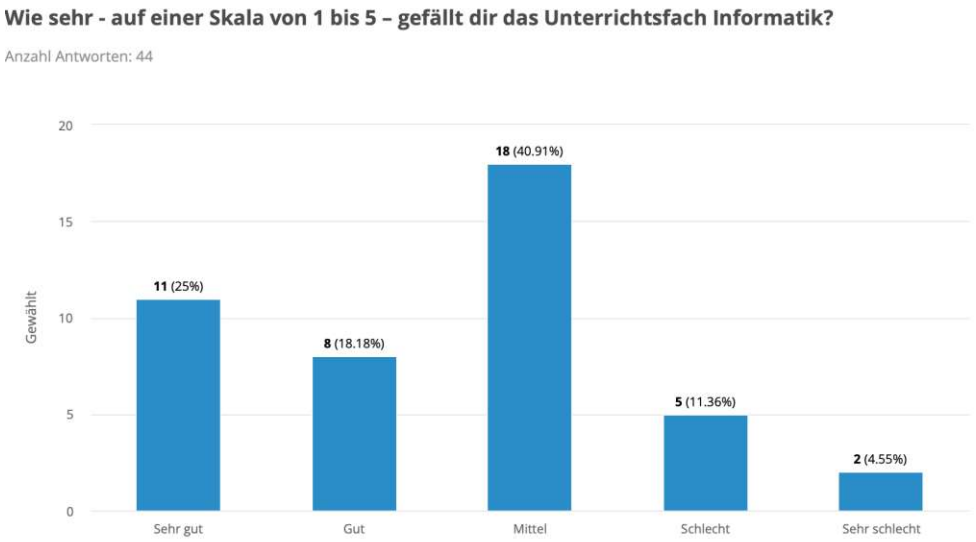


Figure 6.2: On a scale of 1 to 5, how much do you like the subject of Informatics?

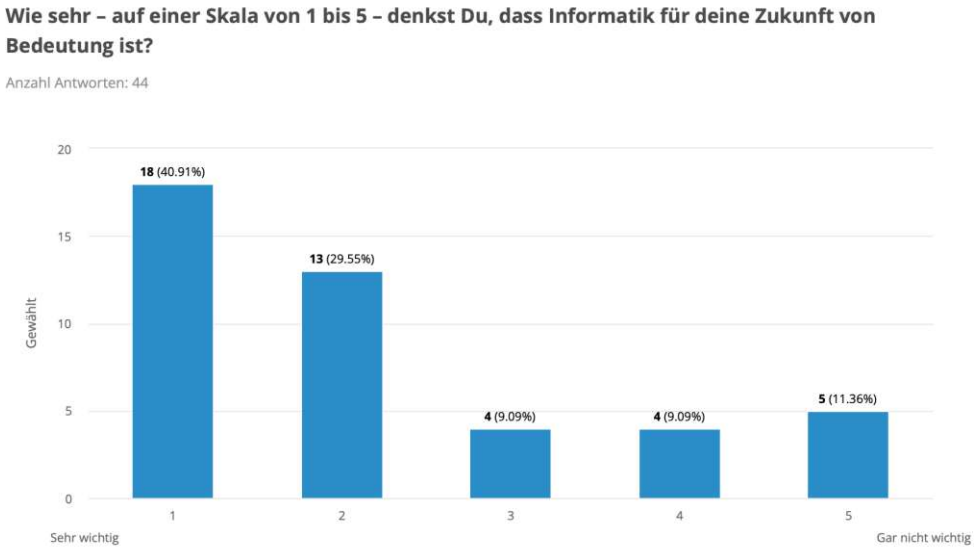


Figure 6.3: How much - on a scale of 1 to 5 - do you think Informatics is important for your future?

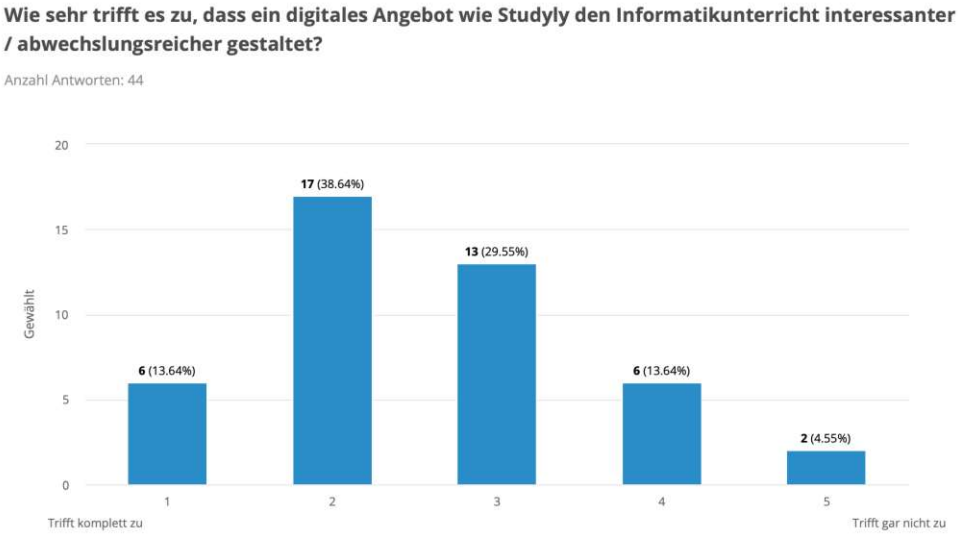


Figure 6.4: How true is it that a digital offer like Studyly makes Informatics lessons more interesting / more varied?

IQ4: How true is it that a digital offer like Studyly makes Informatics lessons more interesting / more varied? (Results see Fig. 6.4)

Now the questions become Studyly focused. Goal of this and the now following questions are to explore the feedback given from the students on the learning platform.

According to the survey, 70% of students claim that they feel significantly more motivated to engage with learning platforms like Studyly (that incorporates gamification elements) (For student questionnaires this is rather a high value.). It is clear that the inclusion of game-like features is a key factor in driving student motivation and engagement.

In a recent observation of an Informatics lesson utilizing the Studyly platform (T4 and T5), the author of this thesis noted similar results: The implementation of gamification was highly effective in capturing the attention of the students. It is noteworthy that the implementation of captivating avatar designs and other playful elements was found to have a particularly significant impact on promoting student participation and enthusiasm.

To gain insight into the underlying reasons, please refer to IQ7, where students were prompted to elaborate on why they enjoy using Studyly.

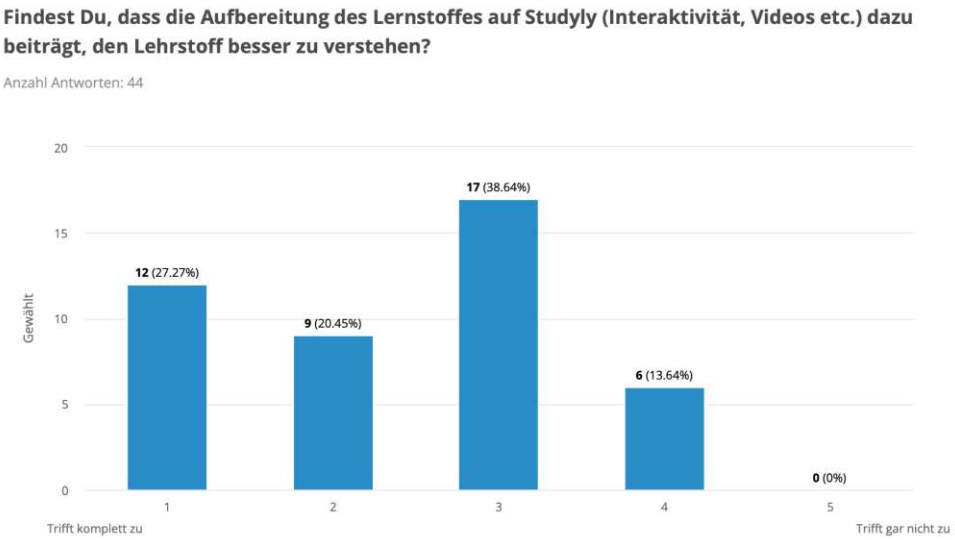


Figure 6.5: Do you find that the preparation of the learning material on Studyly (interactivity, videos etc.) helps to understand the teaching material better?

IQ5: Do you find that the preparation of the learning material on Studyly (interactivity, videos etc.) helps to understand the teaching material better? (Results see Fig. 6.5)

The claim that the presentation of the learning material on Studyly contributes to a better understanding of the subject matter is completely or rather true for over 85 percent.

This statistic serves to reinforce the commitment of this thesis project to utilizing interactive digital tools to facilitate the comprehension of Informatics concepts in a manner that is accessible and pupil-friendly.

The exposition of theoretical concepts has revealed that providing textual explanations alone is inadequate for enabling students, and learners of all levels, to fully comprehend the material. In many cases, further elaboration and contextualization are necessary to enhance understanding (e.g. video explanations, detailed calculations, simulations etc.).

This field is constantly evolving, so it's crucial to use modern technology to help students stay up-to-date with the latest developments and learn in the most effective way possible.

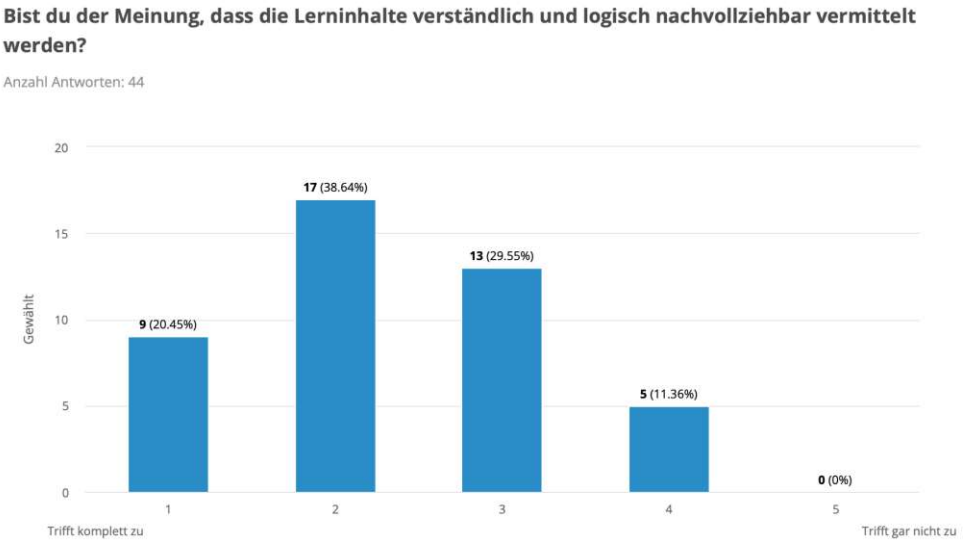


Figure 6.6: Do you think that the learning content is conveyed in a comprehensible and logical way?

IQ6: Do you think that the learning content is conveyed in a comprehensible and logical way? (Results see Fig. 6.6)

Most of the participants also highlighted the clear and well-structured presentation of the content. This underscores the significance of the comprehensive analysis conducted prior to the development of a goal-oriented teaching approach.

It can be stated that the scientific considerations in this regard have been the reason for such an outcome.

IQ7: Can you please name three aspects that you particularly like about Studyly?

As expected, there were relatively many different answers to this open question. In order to draw meaningful conclusions, it was necessary to categorize the responses into different categories. The categories into which the answers have been clusterized are the following:

- gamified learning experience
- enhanced learning through interactive content
- design of the learning platform (layout, structure etc.)

Gamified learning experience

When it comes to the gamified learning experience, 35% of all responses could be categorized into this category, which amounts to a total of 13 responses. This figure represents a significant increase compared to a similar study conducted by the author for final exams in mathematics, where the number was around 20% (study to be published beginning of 2024, first results).

The responses highlighted various gamification elements, including avatars, shops, orbs, and other playful elements. Based on some of the sample responses, it can be inferred that students tend to prefer learning with Studyly, which incorporates gamification, over traditional textbooks.

"Das man schneller und verständlicher und motivierter lernen kann", "Avatar, Shop, Orbs", "Es macht Spaß Es ist so cool. [...]", "Interaktiv, spaßig, unterhaltsam", "spielerische Elemente führen zu mehr Motivation, Avatar gestalten [...]", "spielerische Elemente, Interaktivität, Avatar customizen", "Man kann einen tollen lustigen Avatar erstellen. Man kann seine Fehler angezeigt bekommen. Das Layout ist sehr übersichtlich.", "Punktesystem; Tägliche Challenge; Lernspaß". (The spelling mistakes of pupils have not been corrected in order not to falsify the results.)

Enhanced learning through interactive content

This category encompasses the presentation of learning content to students, along with all the interactive elements involved. Despite only five topic areas being available to students in the pilot application, feedback has been predominantly positive (40% of the responses can be categorized into this category). Here are a few examples of responses:

"Das man schneller und verständlicher und motivierter lernen kann.", "Vorbereitung mit dem Informatik-Kurs", "Nach den Aufgaben gibt es die Lösungen", "Dass sie die Fehler verbessern, dazu andere ähnliche aufgaben darstellen, 2 chancen", "die sofortige Überprüfung, 2 Chancen mit Tipps", "Videos, Lösung mit Erklärung, zweite Chance bei Beispielen", "Man wiederholt die Themengebiete des Unterrichts".

Design of the learning platform (layout, structure etc.)

The "technical aspects" of the platform, such as usability or design, have been included into this category. The feedback was generally positive, with some respondents praising the platform's clear layout, ease of use, and well-designed interface. One respondent stated, *"Übersichtlicher Aufbau, einfach zu bedienen, gut gestaltet".*

IQ8: Can you please name three aspects of Studyly that you don't like?

The purpose of this question is to discuss aspects that could be improved in a future version of the Informatics course. Out of 40 responses, 26 provided negative feedback, while 14 responses stated that there was nothing to improve as they enjoyed the course overall.

The most criticized aspect of the course was the structure of the course and the way problems have been displayed; with some elements being difficult to locate (e.g., *"Fragestellung nicht immer ersichtlich", "Leicht unübersichtlich"*). Additionally, some students did not enjoy the competitive nature of the leaderboard (e.g., *"rangliste"*, *"kompetitive Elemente"*). To address this, a possible solution could be to provide an option to disable gamification features entirely.

Furthermore, three students criticized the registration process (e.g., *"probleme mit anmelden"*), and two reported other technical issues such as videos not playing correctly. Finally, in courses such as cryptography where a large amount of text was included, some students found it too text-heavy (e.g., *"zu textlastig"*). In future versions, new topics could be introduced with a combination of video introductions and written text to address this issue.

6.4.2 Second qualitative interview with two selected schools

Finally, two of the five chosen schools were invited for an in-depth interview to discuss the remaining questions. You can find the interview guide for the second qualitative interview phase in the appendix. We will highlight the aspects not covered in the section before.

The interviews were constructed in a semi-structured way, allowing the interviewer to dive into specific situations in more detail. We have chosen the teachers from the schools (T1) and (T5) from table 6.1 for additional insights.

Teacher (T1) has taught Informatics for over 15 years, and (T5) implements Informatics lessons whenever reasonable in her talent development classes. Both schools have "computer labs" where also those lessons are held. Also, due to the device initiative, the school has established WLAN access points in all classrooms at the secondary level. (T5) has 30 iPads the teachers can borrow when needed. Therefore the device problem - also due to the device initiative - is on track to being solved in Austrian classrooms, making an application such as Studyly also possible in the daily teaching lessons.

(T1) and (T5) have used the topic of cryptography as part of their lessons - based on the author's wish for better comparability. (T1) has taught this in a 50 minutes lesson, (T5) as part of a two-hour lesson. Features that have been most used included the Informatics course - giving homework to the students (as predicted in a previous chapter) has been less important to the teachers. (T1) presented the course on the digital board and asked the students to open it on their devices. The teacher, therefore, had some "main view", and the students followed the teacher's clicking through the interactive course. This could also be experienced with (T5). In a future development step, the software could solve this clicking-through by automatically pushing the current teacher's position in the course to the students.

(T5) has also elaborated on the gamification features that have appealed to the students, especially the leaderboard and the avatar customization.

(T1) summarized the didactical goals of using Studyly in the following way: Through Studyly, the teacher wants to engage students by asking them questions and initiating conversations actively. They shall be "encouraged to participate in group discussions" and "use examples on Studyly to help them understand the material better". She also highlights the advantage of immediate feedback, determining whether they understand the concepts or need further assistance. (T5) agrees with those statements but adds the variety she wants to bring into her classes. With this sort of variety, she aims to keep the students motivated.

They may not have encountered a situation where Studyly didn't support them yet, but it's possible that this is because they haven't been using Studyly for Informatics for that amount of time. However, they have stated that they would like to see it adapted to other areas so that they could use it for the whole school year.

As stated before, Studyly has changed the classes of (T1) and (T5) for the better. According to (T5), it's essential to recognize that certain aspects of learning can be left to the pupils to acquire at their own pace. This, e.g., helps them take responsibility for their education. For (T5), the student's motivation has been higher when they have learned with Studyly compared to the original teaching methods. The students were thrilled: "They jumped up from their sitting, and by their facial expressions and gestures, one just noticed that it was such a big thing for them". The reason for this - according to (T5) - was the gamified version of the course.

Both teachers see Studyly as an enrichment for their classes, not as "a burden". According to (T5), one teacher can focus on other aspects; the "correcting part can be outsourced," and one can focus more on individual learning paths for specific students who are ahead or behind certain topics.

Apart from gamification, the interactivity of the course also supports the teacher in the individualized teaching process. Pupils can learn quickly, e.g., "skipping something if they say they know this topic already" (T1). Both of the teachers agree that with Studyly, the topic stays "more in the head of the pupils" (T5), probably thanks to the "interactivity, the calculation ways, and the gamification elements". (T1) agrees on this,

further elaborating on the possibility of including additional gamification elements. She discusses the point of awarding students with mini-games, e.g., when they have completed a chapter.

Both teachers are keen to use Studyly in the future ("Absolutely 100% in any case."). Features they wish for the future are better syncing of the teacher's position, additional interactive elements (such as HTML5 animations / Jsxgraph) as well as additional gamification elements.

CHAPTER 7

Conclusion

After carefully considering digital development of Informatics, the goal of this master thesis was to determine the optimal way to digitally represent the fifth-grade AHS Informatics curriculum on the Studyly learning platform. It's worth noting that the recent introduction of "Digital Basic Education" ("Digitale Grundbildung") as a required subject in secondary level 1 also adds a new perspective and provides students with early exposure to digital topics.

During this discussion, valuable insights were gained regarding implementing Studyly, including the need to present learning content using interactive elements and manageable portions to maintain students' interest. Actively involving students in this teaching process by considering their knowledge levels and development of tasks was also identified as crucial for keeping them engaged without letting them feel overwhelmed or under-challenged. As a result, the motivation to expand and adapt Studyly, which has already been used for mathematics lessons, to Informatics lessons was significant, particularly given the importance of considering the specific needs of each student. Furthermore, developing the appropriate didactic concept for presenting the topics was deemed essential.

After comparing the different learning platforms in this respect and elaborating on the strengths and weaknesses, we attempted to realize a corresponding offer on Studyly.

Empirical findings, in particular, were also considered for this process. To this end, teachers were interviewed whose statements allowed these literature-related and yet rather general premises to be fleshed out. For instance, the first subject area covered in Studyly, cryptography, was found to be most effectively taught through a practical approach. Real-life references were also identified as crucial to arouse students' interest in topics such as data security and law (topics are in their own life reality!). The interviewed teachers expressed their expectation for Studyly to be utilized in the classroom for lesson planning and to provide engaging and diverse content for students beyond independent

practice tasks. The recommendations from literature and teacher interviews were taken into account as well.

Finally, the pilot phase began, i.e., the actual use of Studyly in Informatics classes. After completing the test phase, Studyly underwent another survey where teachers and students provided valuable insights to aid in the further development of the learning platform. The survey included specific and detailed suggestions to enhance handling and design, which provided essential information for Studyly's future growth and improvement.

Teachers involved in the qualitative studies found Studyly to be an enrichment for their classes, with its gamification features particularly appealing to students. The teachers also appreciated the interactivity of the course, which allowed students to learn at their own pace and be awarded when they have completed some topics (gamification mechanics). Those gamification mechanisms were also highlighted during the students' interviews, especially the avatar design and the leaderboard. Finally, the platform's clear layout, ease of use, and well-designed interface were praised.

This discussion also led to future improvements: Some students criticized the structuring elements of the course, finding some of them needed to be more straightforward and had some navigation problems. A few of them also did not like the competitive leaderboard and suggested that gamification features should be optional. Finally, some students found the course too text-heavy, particularly in cryptography, and suggested introducing new topics with a combination of video introductions and written text. Teachers brought up the aspect of the synchronisation of the teacher's position and additional interactive elements.

CHAPTER 8

Outlook

The thematic arc covered in this work starts with the overarching need for digitization in the education sector. It extends to the specific application of Studyly in Informatics. Drawing on the example of Estonia, this development will likely also take place in Austria.

The Coronavirus experience was one reason why the urgency of successive digitization of the school sector was recognized. The device initiative ("Geräteinitiative"), which accelerated this development as part of the 8-point plan, can only have been a start. Although this initiative means that virtually every student from secondary level 1 onwards should now be equipped with the appropriate hardware, the software and the range of digital learning content need to catch up. While several ambitious projects and successful implementations have been underway for several years in mathematics, the same cannot be said for other subjects or only to a limited extent.

This study aimed to enhance the digitization process of teaching, particularly in Informatics. The Studyly platform for Informatics offers interactive and engaging classroom activities that aim to not only facilitate digitization but also foster students' enthusiasm for the subject. The platform also promotes the sensible use of end devices and enables teachers to allocate their resources more effectively.

In the future, the challenge will be to provide digital offerings for other subjects that enrich everyday school life and demonstrate organizational benefits, e.g., for "home schooling". Since the device initiative already fulfills the fundamental prerequisite, i.e., end devices with the latest technical equipment, a bold and visionary approach is necessary. Learning platforms like Studyly must be created analogously or appropriately adapted.

However, this radical change can only succeed if all stakeholders work together. In addition to political commitment, openness and acceptance on the part of the teaching staff are essential for such digitalization efforts to be successful. Many decision-makers are involved in using digital technologies and must promote them. This can only happen

if each group of stakeholders recognizes the value and specific benefits of corresponding learning platforms.

CHAPTER 9

Appendix

9.1 Interviewleitfaden 1

Danke, dass Sie sich zu diesem Gespräch bereit erklärt haben. Beginnen möchte ich damit, Ihnen kurz das Konzept von Studyly zu erklären und Ihnen die Plattform vorzustellen. Gleichzeitig gehe ich auf die Unterschiede zwischen dem Einsatz von Studyly für Informatik und Mathematik ein, da sich die jeweilige Nutzung naturgemäß in der Didaktik unterscheidet. Die auf der Plattform im Sinne eines Kurssystems aufbereiteten Themengebiete sollen etwa im Unterschied zu Mathematik vor allem der Unterrichtsgestaltung dienen, weniger der Verwaltung und Korrektur von Hausübungen oder dem selbständigen Üben von Seiten der Schüler.

- Kennen Sie Studyly und / oder haben Sie es bereits für Ihren Unterricht genutzt?
  - Falls nein, wird Studyly detailliert erklärt.
  - Falls ja, dann direkt weiter mit Frage 2.
- Bezogen auf das Themenfeld der Verschlüsselung: Wie vermitteln Sie diese Inhalte in Ihrem Unterricht?
- Ich möchte an Ihre Ausführungen gleich anknüpfen: Was beziehungsweise welche Vermittlungsformen erwarten Sie sich von einer digitalen Plattform, damit Sie diese auch sinnvoll für das Themengebiet der Verschlüsselung, aber auch darüber hinaus grundsätzlich im Unterricht integrieren können?
- Falls Sie bereits Erfahrungen mit anderen Lernplattformen dieser Art haben: Was ist Ihnen dabei besonders wichtig? Was muss ein solches Angebot Ihrer Meinung nach auf alle Fälle können?

- Nun darf ich Ihnen bitte die Umsetzung der Inhalte auf Studyly präsentieren und Ihnen das Konzept dahinter näherbringen.
- Darf ich Sie nun bitten, mir Ihre diesbezügliche Meinung mitzuteilen? Was davon finden Sie gut, welche Bereiche sehen Sie kritisch?
- Können Sie sich prinzipiell vorstellen, Studyly in Ihrem Informatik-Unterricht einzusetzen?

9.2 Quantitative Umfrage mit Schüler_innen

- Ich bin... *["männlich" / "weiblich" / "divers"]*
- Wie sehr - auf einer Skala von 1 bis 5 – gefällt Dir das Unterrichtsfach Informatik? *["Sehr gut" bis gar "Sehr schlecht"]*
- Wie sehr – auf einer Skala von 1 bis 5 – denkst Du, dass Informatik für Deine Zukunft von Bedeutung ist? *["Sehr wichtig" bis gar "nicht wichtig"]*
- Wie sehr trifft es zu, dass ein digitales Angebot wie Studyly den Informatikunterricht interessanter / abwechslungsreicher gestaltet? *["Trifft komplett zu" bis "trifft gar nicht zu"]*
- Tragen Lernplattformen wie Studyly dazu bei, mit mehr Motivation die Lerninhalte zu erarbeiten? *["Trifft komplett zu" bis "trifft gar nicht zu"]*
- Findest Du, dass die Aufbereitung des Lernstoffes auf Studyly (Interaktivität, Videos etc.) dazu beiträgt, den Lehrstoff besser zu verstehen? *["Trifft komplett zu" bis "trifft gar nicht zu"]*
- Bist Du der Meinung, dass die Lerninhalte verständlich und logisch nachvollziehbar vermittelt werden? *["Trifft komplett zu" bis "trifft gar nicht zu"]*
- Kannst Du bitte drei Aspekte nennen, welche Dir an Studyly besonders gefallen?
- Kannst Du bitte drei Aspekte nennen, welche Dir an Studyly nicht gefallen?

9.3 Interviewleitfaden 2

9.3.1 Allgemeines

- Wie viele Jahre unterrichten Sie bereits Informatik?
- Können Sie bitte in Bezug auf den Schulstandort beziehungsweise die vorherrschende technische Ausstattung (Räumlichkeiten, Anzahl an Computern, wo findet der Informatikunterricht statt) etwas sagen?

9.3.2 Konkretes

- Wie haben Sie Studyly während der Testphase eingesetzt?
  - Auf welche Lerngebiete bezogen?
  - Häufigkeit?
  - Welche Funktionen haben Sie hauptsächlich genutzt?
- Welche didaktischen Ziele verfolgten / verfolgen Sie mit dem Einsatz der Plattform?
- Gab es Situationen / Themengebiete, in denen Sie von Studyly nicht wie erwartet unterstützt worden sind?

9.3.3 Sichtweise auf die Schülerinnen und Schüler

- Hat der Einsatz von Studyly den Unterricht als solchen verändert? Falls ja, können Sie Ihre diesbezüglichen Erkenntnisse wiedergeben?
- Wie haben Sie den Umgang von Seiten der Schülerinnen und Schüler mit Studyly wahrgenommen?
  - Interesse / Motivation?
  - Handhabung (problemlos oder nicht)?
  - Wobei gab es konkret Probleme beziehungsweise fehlende Bereitschaft, sich mit der Plattform auseinanderzusetzen?
- Grundsätzlich: Erlebten / Erleben Sie den Einsatz von Studyly eher als Bereicherung oder gar als Mehraufwand für Sie?

9.3.4 Lernfortschritt

- Sorgte der Einsatz von Studyly für zusätzliche Motivation beim Erarbeiten der Lerninhalte?
- Im Vergleich zu Ihren Erfahrungswerten: Hat Studyly zu einer Verbesserung der fachlichen Kompetenzen der Schülerschaft beigetragen?
- Falls ja, welche Elemente von Studyly, denken Sie, sind dafür verantwortlich?
  - Erklärschritte?
  - Ständige Rückmeldung bezüglich Status Quo?
  - Gamification?

9.3.5 Ausblick

- Können Sie sich mit der Vorstellung anfreunden, Studyly auch zukünftig in Ihren Unterrichtsablauf zu integrieren?
- Was beziehungsweise welche konkreten Anwendungsmöglichkeiten würden Sie sich zusätzlich – neben den aktuell angebotenen Möglichkeiten – von Studyly erwarten?

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