The implementation of learning apps in biological education: a quantitative study of the current situation in Austria

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Abstract

Purpose – This research paper aims to provide information about certified learning apps for biological education and gave an ordered list of all learning apps currently used by Austrian biology teachers in the classroom, which should serve as an overview for all biology teachers. In addition, the (currently little known) certification process of learning apps (seal of quality for educational applications) is described.

Design/methodology/approach – Online questionnaire for all biology teachers throughout Austria, on the one hand to find out the apps, and on the other hand to research how Austrian teachers find suitable apps. The data were evaluated using descriptive statistics.

Findings – A total of 84 different learning apps are currently used by biology teachers in Austria. There are two certified lernapps in Austria, both are used. The most common app in biology lessons is "Anton". The teachers find the information about apps throughout their own research or through colleagues. There are regional and school-specific differences in regards of usage and knowledge about seal of quality. It needs its own teacher training (TT) via suitable learning apps, because problems (data protection, advertising) are sometimes not taken into account during use.

Research limitations/implications – Limitations of this paper are that some of the teachers indicated the apps from other subjects (mathematics) to use this learning app, although this is not possible for biology lessons. Data protection was stated to the best of the authors' knowledge by the authors, if the authors were not sure it says "unsure". The participants are mainly women, but this corresponds to the gender ratio, which is typical of the Austrian teaching profession.

Practical implications – The overview of the apps, compiled by this Austria-wide research, can be taken over into the biology lessons of all teachers. In addition, on the basis of this study, a TT at the University of Education 2023 in Linz was created. In addition, the (currently little known) certification process of learning apps is described.

Social implications – The TT and the overview of the learning apps used serve as guidelines for teachers as to which apps they can use in biology lessons without hesitation. Above all, the aspect of the follow-up of digital media/apps will be emphasized. Data backup, inappropriate advertising must be processed in class or completely omitted. Biology teachers need the right training (TT) and appropriate materials and tools (apps) to reduce problems (cybercrimes).

Originality/value – Currently, there is no prepared list of suitable (certified and uncertified) learning apps for biology lessons. There are isolated recommendations and individual apps, but the selection criteria and backgrounds of the authors are not clear. This list shows which apps (how often) are used by which teachers. In addition, the (currently little known) certification process of learning apps is described.

Keywords Biology, Education, Educational application, Learning app, Science, STEM, Teacher

Paper type Research paper

Introduction

The COVID-19 pandemic and digitization (BMBWF, 2020a) have drastically changed Austrian teaching in recent years. Distance learning, hybrid teaching, tablet classes, and a new subject "Digital Education" (BMBWF, 2020b) have recently caused many teachers quite a bit of a stir and presented them with many new challenges (Hörmann *et al.*, 2021; Hörmann *et al.*, 2022; Hörmann *et al.*, 2023). Within emergency remote teaching (ERT), educational applications (learning apps) were increasingly used in distance and hybrid teaching (Hörmann *et al.*, 2021). Nevertheless, neither then nor now was there a suitable overview with accompanying materials of existing learning apps for the subject "Biology", which covers most of the teaching content, is GDPR compliant (data protection)and affordable for everyone.

Today, if a biology teacher wants to use an educational application, you are faced with one big question: "*Which learning app can I use in my classroom?*". As a result, in the App stores and online, teachers can find numerous apps (Papadakis and Kalogiannakis, 2017), especially for younger students (Bouck *et al.*, 2016), that are associated with the topics "education" or "biology". Teachers do not want to use "any" learning app, because the mobile or web-based application should be suitable for their lessons, but what criteria do educators use to select them? It is criticized by researchers that there are no apparent quality criteria on the basis of these, how and which learning apps are selected (Papadakis and Kalogiannakis, 2017; Harrison and Lee, 2018). Although there are many specific websites, blogs, print media, or podcasts currently available that review learning apps, according to Papadakis, most of them do not utilize an adequate scientific quality assessment (Papadakis and Kalogiannakis, 2017; Papadakis, 2021).

In a desperate need to create a standard for quality and an overview for all certified learning apps, some EU countries (e.g. Finland, Austria) are now beginning to instrumentalize websites and specific quality assessments based on quality criteria in their countries (BMBWF, 2021; Education Alliance Finland, 2021). In Austria, the Ministry of Education, Research and Development (BMBWF) formed in 2021 a model for quality criteria regarding web-based and mobile educational applications through a state-controlled quality assessment procedure (OeAD, 2021; BMBWF, 2021). With the certification of learning apps, the fifth point of the eight-point plan for digital teaching of the Federal Ministry of Education, Science and Research (BMBWF) is realized (BMBWF, 2020a). The evaluation and certification, performed by the Ministry of Education, and the Austrian Agency of Education and Internationalization (OeAD) (OeAD, 2021; BMBWF, 2020a, 2021), introduce quality assurance. The associated "seal of quality" is intended to offer teachers, students, but also legal guardians, and other interested parties orientation in the selection of learning apps (OeAD, 2021). The eight-point plan for the digitization of Austrian schools involves all central areas of the education system that are necessary for high-quality, future-oriented school operations (BMBWF, 2020a, 2021).

Austrian certification process and current status of certified science apps in Austria

Therefore, to answer the question: "How can a learning app get the Austrian seal of quality (German: Gütesiegel), and how does the certification process work?". The certification procedure is standardized in several steps over a period of several months (OeAD, 2021; BMBWF, 2021). First, app developers submit the app for the certification process, which then are checked for elimination criteria (e.g. available for both iOS/Android, General Data Protection Regulation-compliant (GDPR), no advertising) by the OeAD. After a positive analysis and assessment by three evaluators (in-service teachers), on the basis of an evaluation grid (OeAD, 2021; BMBWF, 2021; Schmidthaler *et al.*, 2022), the app receives the "seal of approval" for two years and is publicly marked as "certified" on the OeAD website (OeAD, 2021). Currently (January 2023), there are 35 certified learning apps for 20 subjects

available in Austria (OeAD, 2021). Therefore, not all school subjects and school levels (only secondary school) are covered. In addition, all certified apps are provided for fifth grade and higher, 24 are free of charge (OeAD, 2021; Schmidthaler *et al.*, 2022) and only two certified apps, "Anton'" and "App ins Holz", are available for the subject "Biology" for all Austrian secondary schools (OeAD, 2021).

Definition: what is an educational application?

According to the OeAD, an educational application (learning app) is defined as a mobile or web-based "*digital tool that supports independent and interest-driven learning activities as well as learning in the context of school lessons, in which students can develop, practice, deepen, repeat, structure, or apply learning content independently of time and place and pursue their own areas of interest*" (OeAD, 2021). In addition, the app is not an organization tool (e.g. calendar). Moreover, the app is no reference work (e.g. term definition), does not serve to design the learning environment and it does not rely exclusively on user-generated content (OeAD, 2021). However, other researchers define an educational application as a mobile learning application (for Smartphone or tablet), designed to assist the user (e.g. children of all ages, students, parents, educators and educational institutions) with remote learning, and gaining knowledge of any kind (Shokurova, 2021; Papadakis *et al.*, 2017; Papadakis and Kalogiannakis, 2017). In the context of this article, educational applications are mobile or web-based learning apps which actively support students or teachers in their learning process, in class or in their leisure time (e.g. lesson preparation, correction, homework and fieldwork).

Benefits of educational applications

There are multifold advantages regarding the utilization and implementation of learning apps into the learning process and education, according to current research (Shokurova, 2021; Camilleri and Camilleri, 2019; Qing, 2017). By definition, a learning app assists its user within their learning process (Shokurova, 2021; Schmidthaler *et al.*, 2022). Additionally, they are user-friendly, and can be employed, regardless of location and time, to provide information very quickly. They are oftentimes more specific or up-to-date than analogue material (e.g. printed literature). In addition, in terms of the weight of the school bag, digital technologies are more back-relieving for the students (Camilleri and Camilleri, 2019, 2020; Qing, 2017; Schmidthaler *et al.*, 2022; Papadakis, 2021). The apps' design and tasks (e.g. providing immediate feedback, error detection, quizzes, exercises and multimedia features) are simplifying the learning procedure and assist the user (e.g. students or teacher) to learn in an intuitive and automatic way (Papadakis *et al.*, 2017). Therefore, according to many studies done by the authors and other researchers, learning apps have the possibility to increase fun, engagement, commitment, self-confidence, collaboration and learning outcomes during a lecture, by possibly working at their own individual level (Alonso-Martinez *et al.*, 2019; Gangaiamaran and Madhumathi, 2017; Camilleri and Camilleri, 2019, 2020; Qing, 2017; Shokurova, 2021; Schmidthaler *et al.*, 2022, 2023a, b; Papadakis, 2021; Shapley *et al.*, 2011; Saidin *et al.*, 2015; Kruchinin and Bagrova, 2021; Harrison and Lee, 2018). Moreover, besides the many student-centered advantages, there are also recommendations from the BMWBF, to use the latest digital technologies in school (BMBWF, 2018, 2020a).

Disadvantages of educational applications

In addition to these many advantages, however, there are also concerns and drawbacks in terms of using learning apps. Some educators and guardians are worried that the

students will become dependent on their smartphone applications and therefore neglect real-life social contact. Furthermore, there are concerns that whilst learning with the smartphone (m-learning), notifications from other apps (e.g. social media) could distract children. Therefore, these disturbances and distractions might prevent learning success and could lead to undesired learning outcomes (Schmidthaler *et al.*, 2022, 2023a; Papadakis and Kalogiannakis, 2017; Dong *et al.*, 2020). Furthermore, for effective usage, WIFI or mobile data, as well as technical devices are required, and not every student or teacher can fulfill these technical requirements. In addition, some learning apps are not free of charge, are not data protection compliant, contain advertising, in-app purchases, incorrect or incomplete information, or (age-)inappropriate content (BMBWF, 2021; Schmidthaler *et al.*, 2022, 2023a; Papadakis and Kalogiannakis, 2017; Dong *et al.*, 2020). Therefore, there is a high demand regarding assistance and quality assessment for teachers, parents and students, to help them not wasting their time utilizing inferior or inappropriate apps (Papadakis *et al.*, 2016).

Educational applications in biological education

As the employment of learning apps by students and educators in biology lessons increased, the number of research has expanded as well in recent years. There is plenty of literature in combination with learning apps from mainly four biological areas: (1) Identification of Living Beings, especially plant determination (e.g. "Pl@ntnet, "Picture it", "Google Lens", "Flora incognita") (Lang and Šorgo, 2022; Mäder *et al.*, 2021; Schmidt and Steinecke, 2020; Otter *et al.*, 2021; Joly *et al.*, 2016; Shapovalov and Andruszkiewicz, 2020; Bilyk *et al.*, 2020), (2) Human Anatomy (e.g. "Insight heart", "3D Anatomy") (Schmidthaler *et al.*, 2023a), (3) Cell Biology (e.g. "iCell", "3D Cell", "Mitosis"), and (4) Sustainability (e.g. "Codecheck App").

Joly *et al.*, tried to find out if Pl@ntnet could be effectively used as a sustainable determination tool. This analysis clearly showed the high attractiveness of the app as well as the potentially huge amounts of botanical observations that could be produced and observed. On the other hand, the limitations of current data flows were also highlighted (especially the bottleneck in validation) (Joly *et al.*, 2016). In another study (2022), Pl@ntnet was tested with 86 secondary school students. Students had to identify six plants with the Internet, with the app, and with the textbook. Results showed that children had the least problems using the app (with the Internet solely the most) but preferred to use a textbook. The authors propose a combination of Pl@ntNet and a pictorial identification key for identification exercises (Lang and Šorgo, 2022). Otter *et al.* (2021) did a comparison of popular iPad applications: Picture It, Pl@ntnet and PlanSnap. Seventeen toxic plants could be identified with those three apps. Findings indicate that PictureThis had the best performance (59% correctly), followed by Pl@ntnet (47%), and PlantSnap (5.8%). The authors suggest that Pl@ntnet and Picture It could be of assistance in identifying toxic plants (Otter *et al.*, 2021).

The second biological topic area where learning apps are used is in cell biology. Mobile applications and their educational quality were already assessed (de Oliveira and Galembeck, 2015; Stark, 2012). Stark (2012) provides an overview and description of cell biology educational apps for Apple devices regarding this topic (Stark, 2012). In another study by Lustosa de Oliveira and Galembeck (2015), 97 cell biology apps were surveyed in order to identify whether there are new approaches for modeling cells using the latest technologies. Findings indicate that cell apps might perform an essential role in cell modeling, because of their sophisticated design with easy-to-use features. The authors concluded that most of the analyzed learning apps for cell biology have a "*great potential to expand the practice and delivery of cell biology teaching and many other areas in biological education*" (de Oliveira and Galembeck, 2015).

The third major area where biological learning apps are more likely to be used is the wide field of human anatomy (Çelik *et al.*, 2020), especially apps with augmented reality (AR)

functionality or 3D visualization, such as 3D Anatomy or Insight Heart. Research regarding the perceptions of Austrian teachers and students on mobile AR apps (mAR) has already been done by the authors (Schmidthaler *et al.*, 2023a). Studies show that mAR enables complex and abstract biological content and concepts to be better understood and visualized for students (Yapıcı and Karakoyun, 2021; Fuchsova and Korenova, 2019; Çelik *et al.*, 2020). Henceforth, it is no surprise that educators are more likely to implement such promising mobile AR apps in their biological education classes (Çakır *et al.*, 2021).

There are also many studies on the subject of "sustainability" in connection with learning apps, such as Codecheck App or Labels for your Planet (Vortmann, 2019; Alonso-Martinez *et al.*, 2019). The findings of a study (2019) indicate that through the employment of learning apps in the classroom students showed an expansion of their interest in environmental issues. The authors suggested teaching sustainability and environmental topics in a combination with more traditional teaching methods to increase the students' learning effects (Alonso-Martinez *et al.*, 2019). In a secondary school experimental study with students on microplastics in cosmetic products, the authors refer to the possible use of the app in combination with a physical experiment in school (Vortmann, 2019).

Description and research regarding "Anton" and "App ins Holz"

In the learning app "App ins Holz" biological topics, such as ecology of the forest, wood, paper and climate protection, are discussed. The app includes flashcards and has a quiz function. Furthermore, the application is ad-free, GDPR compliant, and available for free download in the App Store (Android and iOS), as well as free of charge as a web-based app on all devices (as shown in Table 2). The app was developed as part of a "citizen science project" of the Innovation Foundation Education. Particularly noteworthy is the free manual for the app, which students, teachers and parents can download, and the feature that users have to reach a predefined weekly goal (Pro:Holz, 2022).

"Anton" is the learning app for many subjects besides biology (including Russian, Ukrainian, German, German as a foreign language, Mathematics, Physics, etc.) from preschool to higher secondary school (Anton, 2020). The app currently contains over 100,000 tasks, 200 interactive exercise types, explanations and learning games, and is constantly updated and supplemented. Like "App ins Holz", all learning content is free of charge and without advertising (as shown in Table 2) (Anton, 2020; Apple, 2022). "Anton" is GDPR compliant, and includes rewards (e.g. collecting stars and trophies), quizzes, and games. Moreover, the app can be useful for teachers and school classes, because it allows the user to create an entire school class, assign tasks and track learning progress (Anton, 2020; Apple, 2022).

Name	School level Seal of quality	Biological Content
Anton ANTON (Anton, 2020)	5-8 until: 31.08.203	From the 5th grade: "teaching of living beings", "farm, domestic and wild animals", "birds", "fish, amphibians, reptiles", "seed plants", "the human body" and "health-conscious living". From grade 7: Topics "basic building block cell", "vertebrates", "invertebrates", "forest ecosystem", "water ecosystem", "urban ecosystem", "material and energy conversion in plants", "human: sensory organs", and "human: health and disease"
App ins Holz (Pro:Holz, 2022)	5-13+ until: 30.05.2024	From the 5th grade: "forest ecosystem", "trees", "wood (processing)", "paper (production)", "occupations and training", "climate (protection)", and "sustainability"

Source(s): Table by authors

Table 1.
Comparison and logos
of the certified learning
apps "App ins Holz"
(Pro:Holz, 2022) and
"Anton" (Anton, 2020)

With the certified learning app "Anton" (Anton, 2020), a qualitative study was carried out on the importance of the mobile app in the subject "German as a second language". The authors conclude that "Anton" is recommended for beginners with only little language skills, but to be able to speak and write a new language really fluently, the app is not sufficient (Erim and Sarı Bıyık, 2021). However, considering an article in "Medienimpulse" (2019), the app for language learning is mentioned very positively and is recommended for teaching (Rotschopf, 2019). Furthermore, "Anton" is also recommended to educators because the app can be used as an aid for targeted, and to use interaction-based teaching as mobile applications can be an enrichment for all learners (Erim and Sarı Bıyık, 2021). Clemens and Thibaut (2020) describe that during the COVID-19 pandemic, the app was used in elementary school. It is criticized that the sole use of "Anton" in distance teaching has no advantages for the relationship level between students, parents and teachers (Clemens and Thibaut, 2020).

In another study, in which "Anton" was used in mathematics lessons, the participating students showed increased and sustained motivation in learning, as well as an increased willingness to make a higher effort compared to analog learning methods. As a result, the authors conclude that digital learning with the app "Anton" for targeted tasks is a decisive factor influencing the learning success of the students (Müller and Sagmeister, 2022). Both apps ("App ins Holz" and "Anton"), are advertised online on the official Austrian website for teachers (Lehrerweb, 2022), but scientific studies related to the subject of biology are completely missing. There are no studies on "App ins Holz" yet, as the app is still very new and has only recently appeared on the market (Pro:Holz, 2022).

Methodology
Research question and aim
The main aim of this research is to provide an overview of the learning apps which are currently used by biology teachers in Austria. Concerning this research, the overview of all learning apps in biology lessons as well as their descriptions will be published as Open Educational Resource (OER) on a website accessible to everyone (COOL Lab, 2020), and serves a basis for upcoming teacher training (TT) in 2023 at the University of Education in Linz ("Pädagogische Hochschule").

In addition, it was also investigated where Austrian biology teachers receive information about suitable learning apps. Secondly, this study wants to find out whether Austrian biology teachers use certified educational applications and visit the website for certified learning apps (BMBWF, 2021) promoted by the Ministry and the OeAD in their search for apps, or not.

Austrian states	n = 117	n in %	School types	n = 117	n in %
Upper Austria	27	23.08	Middle school (MS)	62	52.99
Carinthia	0	0.00	Polytechnic school (PTS)	4	3.42
Vienna	12	10.26	Special education and inclusive education	25	21.22
Burgenland	1	0.85	General lower secondary school (AHS)	26	22.41
Lower Austria	61	52.14	General higher secondary school (AHS)	25	21.37
Styria	5	4.27	Vocational school (BS)	0	0.00
Salzburg	3	2.56	Vocational middle School (BMS)	5	4.27
Tyrol	4	3.42	Vocational higher school (BMHS)	11	9.40
Vorarlberg	4	3.42	Primary school (P)	0	0.00

Source(s): Table by authors

Table 2.
Distribution of the Austrian states and school types according to the employment location of the participants (n = 117)

Data collection and processing
The data of the Austrian biology teachers were collected via an online survey using the tool LimeSurvey and took place from September 2022 until December 2023. The questionnaire (target group: all Austrian biology educators) was sent out to more than 400 schools from every federal state. It consisted of demographic questions, one open-ended, and five closed-ended questions (Yes/No (y/n), multiple choice (MC), and single choice (SC):

(1) Do you know what a learning app is? (y/n)

(2) Do you use learning apps in your biology lessons? (y/n)

(3) If yes, which learning apps do you use in your biology lessons?

(4) Do you know the "Seal of Quality" for learning apps in Austria? (y/n)

(5) How do you find a suitable learning app for your lessons? (MC)

(6) Which one of the mentioned options is your preferred method for finding a new learning app? (SC)

All the quantitative data were processed using descriptive statistics (via spreadsheet), as recommended in similar studies (Anđić *et al.*, 2018, 2019; Mikropoulos *et al.*, 2003) and previously done by the authors (Schmidthaler *et al.*, 2022, 2023a). Additional qualitative data (name of apps), were collected in an Excel Sheet, manually checked, according to exclusion criteria, and entered into a list with several items, based on the evaluation grid of the certification process by the OeAD and BMBWF (e.g. data protection, advertising) (OeAD, 2021; BMBWF, 2021). The following elimination criteria were determined by the authors: (1) "ambiguity" (due to serious spelling mistakes; several similar-sounding apps); "wrong subject assignment", "no learning app by definition".

Sampling
In this mixed-method study 117 (87.18% female, 12.82% male) Austrian in-service secondary school biology educators participated in. The distribution of school types, and participating federal states are shown in Table 1. The average age of participants was 42.85 years (y) (Standard deviation = 11.52 y; Minimum = 23 y; Maximum = 64 y), and had an average service experience of 16.82 y (Standard deviation = 12.07 y; Minimum = 0 y; Maximum = 40 y).

In terms of school location and type of school, only secondary school teachers from all federal states (except Carinthia) took part, but the majority of the teachers surveyed work in Lower Austria (52.14%), followed by Upper Austria (23.08%) and Vienna (10.26%). In addition, predominantly middle school teachers (52.99%), followed by general secondary school teachers (43.78%) and special education teachers (21.22%), answered the online questionnaire, as shown in Table 2.

Results
In the following the quantitative results are provided and presented in two topics:

(1) An Overview of the Implementation Regarding Educational Applications in Austrian Biology Lessons

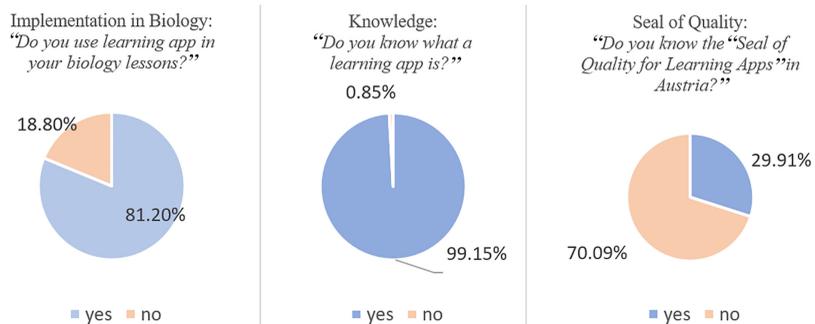(2) Access Possibilities and Usage of the Website "Quality Seal for Learning Apps"

An overview of the implementation regarding educational applications in Austrian biology lessons

When asked if they know what a learning app is, 99.15% of the biology teachers surveyed answered this statement in the affirmative. Also, 81.20% of teachers ($n2 = 95$) are employing learning apps in their biological education, as shown in Figure 1.

The findings of the quantitative online survey showed that 95 participants are using at least one learning app in their biological education, eighteen apps maximum ($n = 117$; arithmetic mean: 2.5; median: 2), as shown in Figure 2. Furthermore, younger teachers, especially 30–40-year-olds, tend to use learning apps in class. In the first years of service and with increasing age, app usage decreases, as shown in Figure 3.

Furthermore, the educators, who know what a learning app is (99.15%) and are app-users ($n = 95$) in their class, are implementing 84 different apps in their biology lessons. Tables 3 and 4 show excerpts of all apps, divided into two groups: apps, which contain biological and science-based content (e.g. "Pl@ntnet", "Seek", "Flora Incognita"; $f1 = 54$) and apps, which do not contain such topics (e.g. "Mentimeter", "Quizlet", "Kahoot"; $f2 = 30$). Further, all apps are distinguished into "non-certified" and "certified" learning apps ("seal of quality"). In addition, they are classified according to whether they are a "web-based" and/or a "mobile" application ("usability"). Moreover, data regarding frequencies of usage and the web-pages of the applications are provided. Furthermore, possible costs, advertisements, data protection

Figure 1.
The app implementation in biology lessons according to participating biology teachers (left), knowledge about learning apps (middle) and the seal of quality and its OeAD website (left) ($n = 117$)

Implementation in Biology: "Do you use learning app in your biology lessons?"
18.80%
81.20%
yes   no

Knowledge: "Do you know what a learning app is?"
0.85%
99.15%
yes   no

Seal of Quality: "Do you know the "Seal of Quality for Learning Apps" in Austria?"
29.91%
70.09%
yes   no

Source(s): Figure by authors

Figure 2.
The number of learning apps used in Austrian biological education according to participants ($n = 117$)

Number of Implemented Learning Apps in Biological Education

Number of Learning Apps ········ Linear (Number of Learning Apps)
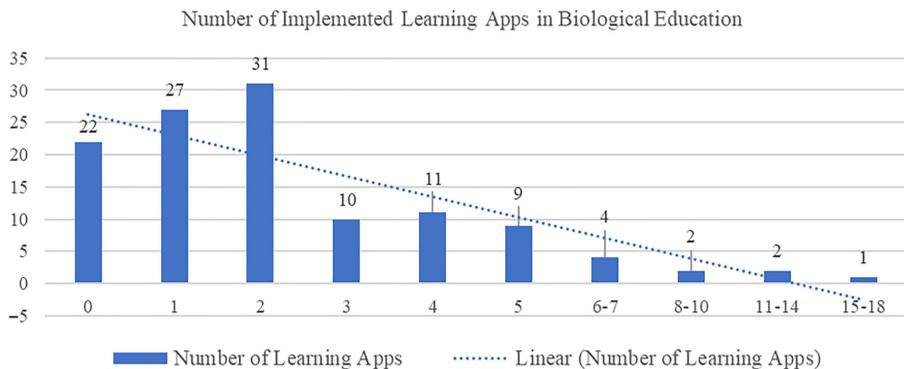
Source(s): Figure by authors
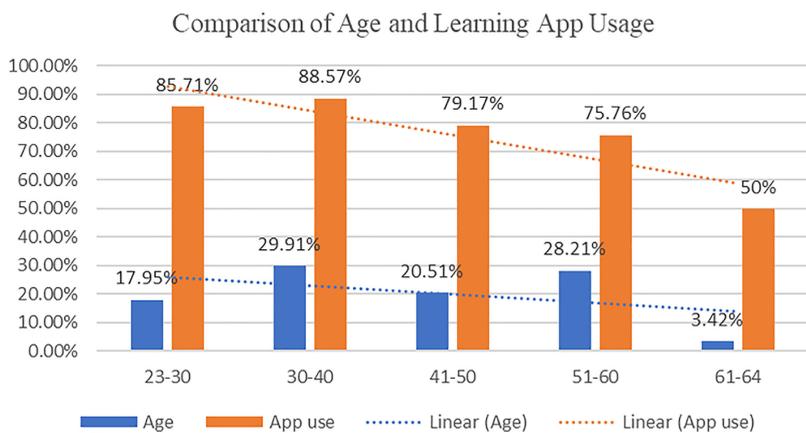
Comparison of Age and Learning App Usage

Figure 3.
Comparison of learning
app usage and age of
participants in
% (n = 117)

(GDPR), in-app purchases, and availability (IOS, Android) are listed in extracts (find the full list in the *Appendix*).

In summary, 95 Austrian biology secondary school teachers use 82 uncertified and two certified ("Anton" and "App ins Holz") learning apps in their lessons. Fifty-four contain full or in parts biological content, and 30 do not have biological or science content whatsoever. The majority of the apps are available as freeware (f = 77), however 30 of the stated learning apps in use provide in-app purchases. Furthermore, 22 contain advertisements, and 30 are not GDPR compliant, or there was no clear evidence regarding data protection found. All evaluated mobile learning apps are available for IOS (f = 45). Only 86.67% of the mobile apps (f = 39) are accessible for Android, and web-based app-users employ 18 (37.5%) applications in their education.

The five most used learning apps in Austrian biological secondary education are "Anton" (55.79%), "LearningApps.org" (48.42%), "Kahoot" (40%), "Quizlet" (12.63%), "LearningSnacks" (7.37%), "Mentimeter" (6.31%) and "Sofatutor" (6.31%). Two educators stated that they develop their own learning apps, and five are using apps from textbook publishers ("Digi4School" or "Veritas").

Apps were not included in the list, if, firstly, they were not a learning app by definition of the authors (e.g. "Moodle", "Schoolfox", "Eduthek"), they were misspelled to the point of being unrecognizable, or there were similar-sounding apps in app stores available (ambiguity) (e.g. "Plus"). Lastly, if the learning app can be clearly assigned to another subject (e.g. "Bettermarks", "Geogebra", "Matheluisa", and "Mathearena" to mathematics), it was not considered either.

Access possibilities and usage of the website "Quality Seal for Learning Apps"

The participating biology teachers stated that they mainly find suitable or new learning apps for their biology lessons through their colleagues (63.25%) or through their own research on the internet (50.43%). These two methods are the first choice of their preferred search method and access possibility (as shown in Figure 4 and Table 5). Respondent two (female, AHS, 29): *"I prefer to hear experience reports (about the apps) from my friends. In practice, my own research on the Internet (for suitable apps) is the first choice"*. Another teacher wrote (Respondent three: female, middle school and special education teacher, 55) that her preferred method is to *"share experiences with (her) colleagues"*. In addition, the participants also get to know new learning apps through the assistance of their friends (17.09%), social media

Table 3.
Excerpt of evaluated mobile and web-based educational applications (f1 = 54), which contain science and biological content, and are currently used by Austrian in-service biology secondary school teachers (n = 95)

	Name of the educational application (with biological/science content)	f	Seal of quality	Costs	In-app purchase	Data protection GDPR	Advertisements	Availability	Usability
1	Anton https://play.google.com/store/apps/details?id=com.solocode.anton&hl=de_AT&gl=US	53	**yes**	no	yes	yes	no	IOS; Android	mobile and web-based
2	Sofatutor https://www.sofatutor.at/; https://play.google.com/store/apps/details?id=com.sofatutor.mobile&hl=de_AT&gl=US	6	no	no	yes	unsure	no	IOS; Android	mobile and web-based
3	Apps from textbook publishers Digi4School: https://digi4school.at/; Veritas: https://www.veritas.at/gratis-app-veritas-mediathek	5	no	no	no	yes	no	IOS; Android	mobile and web-based
4	Helbing e-zone https://www.helbing-ezone.com/?page=de.home&lang=de	4	no	no	no	yes	no	IOS; Android	mobile and web-based
5	Seek by iNaturalist https://www.inaturalist.org/pages/seek_app	4	no	no	no	unsure	no	IOS; Android	mobile
6	Simpleclub https://simpleclub.com/; https://play.google.com/store/apps/details?id=com.simpleclub.android	4	no	no	yes	unsure	yes	IOS; Android	mobile
7	youtube https://www.youtube.com/	4	no	no	yes	no	yes	IOS; Android	mobile and web-based
8	Flora Incognita https://play.google.com/store/apps/details?id=com.floraincognita.app.floraincognita&hl=de_AT&gl=US	3	no	no	no	unsure	no	IOS	mobile
9	Phet Colorado https://phet.colorado.edu/de/	3	no	no	no	unsure	no	IOS; Android	mobile and web-based
10	Pl@ntNet https://play.google.com/store/apps/details?id=org.plantnet&hl=de_AT&gl=US, https://identify.plantnet.org/de-at	3	no	no	no	unsure	no	IOS; Android	mobile
17	Insight Heart https://www.microsoft.com/en-us/p/insight-heart/9nblggh435kd, https://animares.com/	2	no	3,49€	no	unsure	no	IOS; Android	mobile
19	self-made apps by teacher no webpage	2	no	–	–	–	–	IOS; Android	mobile and web-based
24	App ins Holz https://www.helbing-ezone.com/?page=de.home&lang=de	1	**yes**	no	no	yes	no	IOS; Android	mobile and web-based

Source(s): Table by authors

Name of the educational application with no biological/science content	f	Seal of quality	Costs	In-app purchase	Data protection GDPR	Advertisements	Availability	Usability
1 LearningApps.org https://learningapps.org/	46	no	no	no	yes	yes	Browser	web-based
2 Kahoot! https://create.kahoot.it/auth/login	38	no	no	yes	no	no	IOS; Android	mobile; web-based
3 Quizlet https://quizlet.com/de/mobile	12	no	no	yes	yes	yes	IOS; Android	mobile; web-based
4 Learningsnacks https://www.learningsnacks.de/#/welcome?channel=Learning%20Snacks	7	no	no	no	yes	no	Browser	web-based
5 Mentimeter https://www.mentimeter.com/	6	no	no	no	unsure	no	IOS; Android	mobile; web-based
6 Quizizz https://play.google.com/store/apps/details?id=com.quizizz_mobile&gl=US	4	no	no	yes	yes	no	IOS; Android	mobile; web-based
7 Google Forms (MS) https://www.google.com/forms/about/	3	no	no* MS account	no	no	no	IOS; Android	mobile; web-based
8 Padlet https://padlet.com/dashboard	3	no	no	yes	unsure	no	IOS; Android	mobile; web-based
9 Socrative https://www.socrative.com/apps/; https://play.google.com/store/apps/details?id=com.socrative.student&hl=de_AT&gl=US	3	no	no	no	no	no	IOS; Android	mobile; web-based
10 iMovie https://apps.apple.com/at/app/imovie/id377298193	2	no	no	no	no	no	IOS	mobile
11 TikTok https://www.tiktok.com/; https://play.google.com/store/apps/details?id=com.zhiliaoapp.musically&hl=de_AT&gl=US	2	no	no	yes	no	yers	IOS; Android	mobile; web-based

Source(s): Table by authors

Table 4.
Excerpt of evaluated mobile and web-based educational applications (f2 = 30), which do not contain science and biological content, and are currently used by Austrian in-service biology secondary school teachers (n2 = 95)

(13.68%), and school meetings (14.53%). Only a few teachers visit the OeAD website for certified learning apps (9.40%), or get their information directly from the ministry (1.71%), as 70.09% of participants did not even know the OeAD website (Figure 1).

Concerning the federal state comparison with regards to employment location of all participants, in Vienna (33.33%) most teachers know about the seal of approval for learning apps, followed by Lower Austria (31.15%) and Upper Austria (29.63%). In other federal states, no comparison was made due to insufficient number of participants. Four participants (4.26%) visit the website "Quality Seal for Learning Apps" as a first preference in their search for new suitable educational applications (Table 5). One respondent (33, male, general lower and higher secondary school teacher) stated that he *"only uses (his) self-designed apps"*.

With regard to the comparison of school types in terms of employment, it can also be seen that in Austrian middle schools 90.32% of the biology teachers use learning apps in their lessons, followed by general secondary school (AHS: lower 80.77%; higher 76%), as shown in Figure 5. There is a trend that schools with a certain focus (e.g. vocational training, inclusion and special needs) tend to use fewer learning apps. It can also be observed that in schools with younger students (aged: 10–14 y) without vocational training and special care (lower AHS, MS), slightly more biology teachers use learning apps than with older students in higher school classes (BMHS, higher AHS).

Discussion

This study investigated which learning apps are used by Austrian secondary school teachers in biology lessons. Further, it was explored, where do these educators access or find educational applications for their students. The stated learning apps were checked according to predefined exclusive criteria (BMBWF, 2021) and afterward presented in an overview.
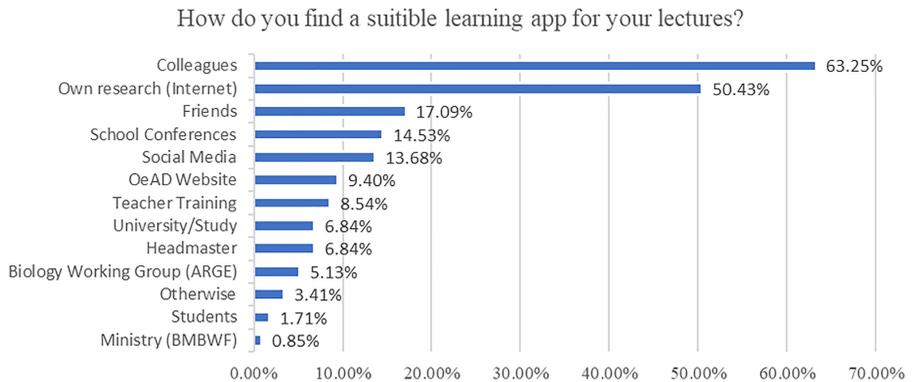
Figure 4.
Overview how Austrian biology teachers find access to suitable learning apps (n2 = 95)

Source(s): Figure by authors

No.	First preferences	f	f in %	No.	First preferences	f	f in %
1	Own Research (Internet)	35	36.84%	5	Teacher Training (TT)	4	4.21%
2	Colleagues	32	33.68%	6	Website (seal of quality)	4	4.21%
3	Otherwise	12	12.63%	7	Friends	2	2.10%
4	Biology Working Group (ARGE)	4	4.21%	8	Social Media	2	2.10%
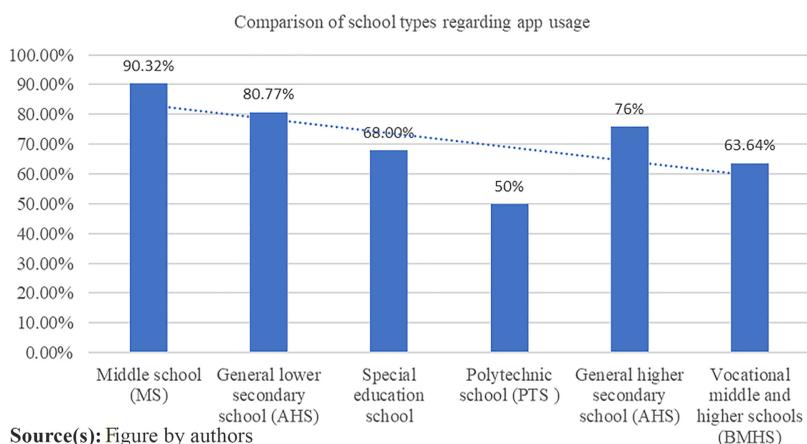
Table 5.
First preferences how Austrian biology teachers find access to suitable learning apps (n2 = 95)

Source(s): Table by authors

Comparison of school types regarding app usage

Source(s): Figure by authors

It is worth mentioning in terms of limitations that predominantly women are participants in this study. However, since no gender-specific links and conclusions have been drawn, and the Austrian distribution in the teaching profession corresponds to that of this study, this point can be neglected (BMBWF, 2020c). Furthermore, it must also be mentioned that there was disagreement regarding three apps and their assignment. Most of the apps that were excluded from the assignment from the final overview table were those that were linked to another subject. It was discussed within the team whether "Schoolfox", "Moodle" and "Geogebra" are suitable learning apps in biological education, since "Geogebra" has the possibility to create a "Geogebra book", with possible use in the subject of biology. "Schoolfox" and "Moodle" finally were excluded because these apps are used by educators in class, for their preparation, communication with students and parents, correction work, or follow-up. Finally, it should be declared that the question regarding the first reference in terms of app search has originally been designed as a SC. The question was mistakenly implemented as an open-ended question in Limesurvey. Therefore, in addition to their first choice, few teachers wrote statements, excerpts of which can be found in the results as direct quotations.

In regard to the final findings, it was pleasing that a certified learning app "Anton" (Anton, 2020; OeAD, 2021), is the most frequently used learning app in Austria according to the participants. Moreover, this circumstance was surprising, as only a few teachers know about the certification process, and therefore about the advantages of the seal of quality. The three most common learning apps ("Anton", "LearningApps.org", "Kahoot") consist of multimedia and quiz features where students can win prizes or compete against other classmates. These additional features have been discovered in other "Kahoot" studies to increase collaboration, engagement, motivation and participation in the classroom (Virga et al., 2022; Bawa, 2019; Zhang and Yu, 2021).

Further, the differences between federal states in terms of the level of knowledge about the seal of quality were striking. Reasons could be the proximity of the Ministry of Education, different assessment strategies throughout the states, or the higher population density in the capital city. It was to be expected that app use decreases with increasing age, but surprisingly many more experienced teachers still use a lot of different learning apps in biology lessons, although the knowledge about the certification is so low, and suitable overviews, as well as additional teaching material are lacking. Therefore, this study can dispel the myth that older teachers refuse to use the latest technologies and apps in relation to biology lessons in secondary education.

In terms of usage, it was noticeable that more MS teachers are app-users than in all other school types. Reasons for this could be on the one hand the school specific focus (vocational training, inclusion), and on the other hand the age of the target group. Nevertheless, there are also differences in terms of implementation in comparison between lower AHS level and MS. In consideration of that, it can be assumed that learning apps are still not rewarded as a sustainable teaching method in the minds of some AHS teachers. Further studies must take place with regard to this presumption.

Due to the often very scarce school budget, it was not surprising that the majority of the apps used were free, or available as a free version, but it is frightening how many teachers use apps, although they sometimes contain inappropriate or annoying advertising and in-app purchases (Schmidthaler *et al.*, 2022, 2023a). This can lead to unwanted subscriptions and further problems with students or parents. Moreover, it seems that in addition to advertising, no attention is paid to data protection. Hence, it can be assumed that some teachers themselves have little or no idea about Data Protection Regulation or other dangers in dealing with learning apps (e.g. inappropriate content (Schmidthaler *et al.*, 2022), or apps in general with chat or comment sections (e.g. "Youtube", "TikTok") (e.g. cybercrimes (Almadhoor *et al.*, 2021)). This circumstance could be due to their possible ignorance, or lack of knowledge or training, partly probably due to time constraints, or the lack of supply. Therefore, there is a great need to stress suitable TT, to firstly provide suitable apps, and secondly, to emphasize the importance of follow-up sessions in school, as part of digital education". Concerning obtaining information about apps for their profession, word of mouth among colleagues is still the number one source of information. This result is not surprising either, and highlights again the importance of TT tailored to biology teachers.

Conclusion and outlook

After the evaluation of the implementation of educational applications in Austrian biology classes it can be concluded that the majority of all Austrian biology teachers in secondary education use 82 different learning apps. The certified learning app "Anton" is the most common besides "Kahoot" and "Learningapp.org", due to their motivating, entertaining and engaging quizzes, and multimedia applications. Furthermore, it can be assumed that many Austrian biology teachers have a lack of knowledge regarding safety issues in terms of learning apps, and there is a great need to fix that issue with special TT.

In order to test the assumption that middle school teachers are more positive about learning apps and that AHS teachers use them less frequently because they do not consider it a suitable teaching method, a qualitative study will be conducted in 2023/24 where biology teachers from both types of schools (MS and AHS) will be interviewed. In addition, another Austria-wide quantitative study regarding motives, opinions and frequency of use will take place in 2023; and an additional qualitative study to highlight strengths and weaknesses for biology teachers and their students in the classroom, according to secondary school teachers, will take place at the beginning of 2023. In addition, on the basis of this study, and additional quantitative results of a second study, a TT ("apps-periments") specially tailored to the wishes and needs of Austrian biology teachers will be developed and will take place at the University of Teacher Education Linz ("Pädagogische Hochschule") in 2023.

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Appendix

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
ABC der Tiere	1	no	12,99*	no	yes	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=air.de.mildenbergerverlag.abc1android&hl=gsw&gl=US; * free demo available
Actionbound	2	no	no	no	yes	no	IOS and Android	mobile and web-based	https://de.actionbound.com/
Akinator	1	no	no	yes	no	yes	IOS and Android	mobile and web-based	https://de.akinator.com/; https://play.google.com/store/apps/details?id=com.digidust.elokence.akinator.freemium&hl=de_AT&gl=US
Anatomy Learning - 3D Anatomy	2	no	no	yes	yes	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.AnatomyLearning.Anatomy3DViewer3&hl=gsw&gl=US
Anatomyka - 3D Anatomy Atlas	1	no	no	yes	yes	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.anatomyka.android&hl=gsw&gl=US
AndyGreen	2	no	no	no	no	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.andygreen.AndyGreen&hl=gsw&gl=US
Anton	53	**yes**	no	yes	yes	no	IOS; Android	mobile and web-based	https://play.google.com/store/apps/details?id=com.solocode.anton&hl=de_AT&gl=US
App ins Holz	1	**yes**	no	no	yes	no	IOS; Android	mobile and web-based	https://play.google.com/store/apps/details?id=at.appinsholz.ovosplay&hl=de_AT&gl=US
Apps des Hauses der kleinen Forscher	1	no	no	no	yes	yes	IOS; Android	mobile	https://kinderleicht.berlin/kleine-forscher/

(continued)

Table A1.
List of all mobile and web-based educational applications (f = 54), which contain science and biological content, and are currently used by Austrian in-service biology secondary school teachers (n2 = 95)

Table A1.

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
Apps from textbook publisher	5	no	no	no	yes	no	IOS and Android	mobile and web-based	Digi4School: https://digi4school.at/; veritas: https://www.veritas.at/gratis-app-veritas-mediathek
Areeka	1	no	no	yes	unsure	no	IOS; Android	mobile	https://areeka.net/support/areeka-app/
Atlas der Humananatomie - Visible Body	1	no	24.99	yes	yes	no	IOS; Android	mobile	https://apps.apple.com/at/app/atlas-der-humananatomie-2021/id1117998129
Aufgabenfuchs	1	no	no	no	no	no	Browser	web-based	https://www.aufgabenfuchs.de/index.shtml
Augment	1	no	no	no	unsure	no	IOS and Android	mobile	https://play.google.com/store/apps/details?id=com.ar.augment&hl=de_AT&gl=US
Binogi.de	1	no	no	yes	unsure	no	IOS and Android	mobile and web-based	https://app.binogi.de/; https://play.google.com/store/apps/details?id=com.ocr.kollpascan&hl=de_AT&gl=US
Biology Mitosis and Meiosis	1	no	no	yes	unsure	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.firstclassstanding.mitosis_meiosis&gl=US
Blossom	1	no	no	yes	no	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.conceptivapps.blossom&hl=gsw&gl=ES
Bones 3D (Osseous System 3D Anatomie)	2	no	no	no	no	yes	IOS; Android	mobile	Bones 3D (Anatomy) on the App Store (apple.com)

(*continued*)

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
card2brain	1	no	no	yes	no	yes	IOS and Android	mobile and web-based	https://card2brain.ch/; https://play.google.com/store/apps/details?id=ch.openconcept.c2b&hl=de_AT&gl=US
ChemgaPedia.de	1	no	no	no	no	no	Browser	web-based	https://www.chemgapedia.de/vsengine/
Clue	1	no	no	yes	unsure	no	IOS; Android	mobile	https://helloclue.com/de
Codecheck	1	no	no	yes	no	yes	IOS; Android	mobile	https://codecheck-app.com/de/ (codecheck-app.com)
Die kleine Waldfibel: Entdecke den Wald	2	no	no	no	yes	no	IOS	mobile	https://apps.apple.com/de/app/die-waldfibel/id453746100; https://www.bmel.de/DE/themen/wald/wald-in-deutschland/wald-app.html
Eduvidual	2	no	no	no	no	no	Browser	web-based	https://www.eduvidual.at/local/eduvidual/pages/login.php
Flora Incognita	3	no	no	no	unsure	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.floraincognita.app.floraincognita&hl=de_AT&gl=US
Flo	1	no	no	yes	unsure	no	IOS; Android	mobile	https://flo.health/
Helbing e-zone	4	no	no	no	yes	no	IOS and Android	mobile and web-based	https://www.helbling-ezone.com/?page=de.home&lang=de
iCell	1	no	no	no	yes	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=icell.android&gl=US; https://icell.hudsonalpha.org/
Immerse	1	no	no	yes	yes	yes	IOS and Android	mobile	https://play.google.com/store/apps/details?id=com.hartrxr.rxrimmerse&hl=de_AT&gl=US

(continued)

Table A1.

Table A1.

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
Insight Heart	2	no	3,49 €	no	unsure	no	IOS; Android	mobile	https://www.microsoft.com/en-us/p/insight-heart/9nblggh435kd; https://animares.com/
Kahn academy	1	no	no	no	yes	no	IOS and Android	mobile	https://play.google.com/store/apps/details?id=org.khanacademy.android&hl=de_AT&gl=US
Labster	1	no	yes*	no	yes	no	IOS and Android	mobile and web-based	https://www.labster.com/; https://apps.apple.com/us/app/labster/id1600663267
LeYo	1	no	no	no	yes	no	IOS and Android	mobile + Picturebook	https://www.appgefahren.de/leyo-buecher-von-carlsen-bilderbuecher-mit-app-anbindung-und-interaktiven-inhalten-173914.html; https://www.apkfollow.com/app/de/leyo/de.carlsen.leyo/
Mallig eduvinet	1	no	no	no	unsure	no	Browser	web-based	https://www.mallig.eduvinet.de/
Mein Körper - Anatomie	1	no	3,49 €	no	unsure	no	IOS	mobile	https://apps.apple.com/de/app/mein-k%C3%B6rper-anatomie/id545172723
Merge cube (Merge EDU Apps)	1	no	25 $*	yes*	yes	no	IOS; Android	mobile*	https://mergeedu.com/merge-cube * additional material (cube) is necessary, Merge EDU apps are free
Mitosis, Meiosis, Organelles	1	no	no	no	unsure	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=info.scienceland.mitosisandmeiosis&gl=US
Mushroom Identify! (Pilzator - Pilzerkennung)	1	no	no	yes	no	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.pingou.champignouf&hl=en_US&gl=US

(*continued*)

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
Naturblick	1	no	no	no	yes	no	IOS; Android	mobile	https://apps.apple.com/de/app/naturblick/id1206911194; https://naturblick.museumfuernaturkunde.berlin/
Phet Colorado	3	no	no	no	unsure	no	IOS; Android	web-based	https://phet.colorado.edu/de/
Picture Mushroom	1	no	no	yes	no	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.glority.picturemushroom&hl=en_US&gl=US; https://picturemushroom.com/
PictureThis	1	no	no	yes	no	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=cn.danatech.xingseus&hl=gsw&gl=ES; https://www.picturethisai.com/de/
Pl@ntNet	3	no	no	no	unsure	no	IOS; Android	mobile	https://play.google.com/store/apps/details?id=org.plantnet&hl=de_AT&gl=US; https://identify.plantnet.org/de-at
Planet-Schule	2	no	no	no	yes	no	Browser	web-based	https://www.planet-schule.de/index.html
Scook	2	no	no	no	yes	no	IOS and Android	mobile and web-based	https://www.scook.at/
Scoyo	1	no	no	yes	unsure	no	IOS and Android	mobile	https://apps.apple.com/at/app/scoyo/id101450359

(continued)

Table A1.

Table A1.

Name of the educational application (with biological/science content)	f n = 95	Seal of quality	Costs	In-app purchase	Data protection/ GDPR	Advertisements	Availability	Usability	Webpages and references
Seek by iNaturalist	4	no	no	no	unsure	no	IOS; Android	mobile	https://www.inaturalist.org/pages/seek_app; https://play.google.com/store/apps/details?id=org.inaturalist.seek&referrer=utm_source%3Dinat-seek-page%26utm_campaign%3DiNaturalist%2520Seek%2520Page%26anid%3Dadmob
Self-made apps by teacher	2	no	–	–	–	–	IOS and/or Android	mobile and/or web-based	no webpage
Simpleclub	4	no	no	yes	unsure	yes	IOS; Android	mobile	https://simpleclub.com/; https://play.google.com/store/apps/details?id=com.simpleclub.android
Sofatutor	6	no	no	yes	unsure	no	IOS; Android	mobile and web-based	https://www.sofatutor.at/; https://play.google.com/store/apps/details?id=com.sofatutor.mobile&hl=de_AT&gl=US
Solar Walk Lite - Planetarium	1	no	no	no	unsure	yes	IOS; Android	mobile	https://play.google.com/store/apps/details?id=com.vitotechnology.SolarWalkLite&gl=US; https://vitotechnology.com/apps/solar-walk-lite
StudySmarter	2	no	no	yes	no	yes	IOS; Android	mobile and web-based	https://www.studysmarter.de/; https://play.google.com/store/apps/details?id=com.studysmarter&hl=de_AT&gl=US
Unterricht.Schule	1	no	no	no	unsure	no	Browser	web-based	https://unterricht.schule/
youtube	4	no	no	yes	no	yes	IOS; Android	mobile and web-based	https://www.youtube.com/

Source(s): Table by authors

Name of the educational application with no biological/science content	f n = 95	Seal of quality	Costs	In-app purchase	Data protection	Advertisements	Availability	Usability	Webpages and references
AnswerGarden	1	no	2.99$ (IOS)*	no	unsure	no IOS yes**	IOS	web-based	https://answergarden.ch/* no costs (webpage) ** yes advertisements (webpage)
Baamboozle	1	no	no	yes	no	yes	IOS and Android	mobile and web-based	https://www.baamboozle.com/; https://play.google.com/store/apps/details?id=com.JustHonour.BamboozleBall&hl=de_AT&gl=US
BBC News	1	no	no	no	no	yes	IOS and Android	mobile and web-based	https://play.google.com/store/apps/details?id=bbc.mobile.news.ww&hl=de_AT&gl=US https://www.blooket.com/
blooket	1	no	no	no	unsure	no	Browser	web-based	https://www.blooket.com/
BookWidgets	1	no	no	no	unsure	no	IOS	mobile and web-based	https://www.bookwidgets.com/; https://apps.apple.com/us/app/bookwidgets/id849068625
Clips	1	no	no	no	no	no	IOS	mobile	https://apps.apple.com/at/app/clips/id1212699939
Code.org - App Lab	1	no	no	no	yes	no	Browser	web-based	https://code.org/educate/applab
Crossword Puzzle Maker	1	no	no	no	no	no	Browser	web-based	https://crosswordlabs.com/
Flipgrid	1	no	no	no	no	no	IOS; Android	mobile and web-based	https://apps.microsoft.com/store/detail/flipgrid/9NQ07X4VJX2S?hl=en-us&gl=us
Flippy Quizzes	1	no	no	no	no	no	Browser	web-based	https://www.quotev.com/quizzes/Flippy

(*continued*)

Table A2.
List of all mobile and web-based educational applications (f2 = 30), which do not contain science and biological content, and are currently used by Austrian in-service biology secondary school teachers (n2 = 95)

Table A2.

Name of the educational application with no biological/science content	f n = 95	Seal of quality	Costs	In-app purchase	Data protection	Advertisements	Availability	Usability	Webpages and references
Google Forms (MS)	3	no	no* MS account	no	no	no	IOS; Android	mobile and web-based	https://www.google.com/forms/about/
H5P	1	no	no	no	unsure	no	Browser	web-based	https://h5p.org/
iMovie	2	no	no	no	no	no	IOS	mobile	https://apps.apple.com/at/app/imovie/id377298193
Kahoot!	41	no	no	yes	no	no	IOS; Android	mobile and web-based	https://create.kahoot.it/auth/login
LearningApps.org	48	no	no	no	yes	yes	Browser	web-based	https://learningapps.org/
Learningsnacks	7	no	no	no	yes	no	Browser	web-based	https://www.learningsnacks.de/#/welcome?channel=Learning%20Snacks
Mentimeter	6	no	no	no	unsure	no	IOS; Android	web-based and mobile	https://www.mentimeter.com/
mindmup	1	no	no	no	yes	no	Browser	web-based	https://www.mindmup.com/
Padlet	3	no	no	yes	unsure	no	IOS; Android	mobile and web-based	https://padlet.com/dashboard
Plickers	1	no	no	no	unsure	no	IOS; Android	mobile and web-based	https://play.google.com/store/apps/details?id=com.plickers.client.android&gl=US; https://get.plickers.com/

Name of the educational application with no biological/science content	f n = 95	Seal of quality	Costs	In-app purchase	Data protection	Advertisements	Availability	Usability	Webpages and references
Playmit	1	no	no	no	no	no	Browser	web-based	https://www.playmit.com/
Quizlet	12	no	no	yes	yes	yes	IOS; Android	mobile and web-based	https://quizlet.com/de/mobile
Quizizz	4	no	no	yes	yes	no	IOS; Android	mobile and web-based	https://play.google.com/store/apps/details?id=com.quizizz_mobile&gl=US
Shadow Puppet Edu	1	no	no	no	unsure	no	IOS	mobile	https://apps.apple.com/us/app/shadow-puppet-edu/id888504640
Sketchbook	1	no	no	no	unsure	no	IOS and Android	mobile	https://play.google.com/store/apps/details?id=com.adsk.sketchbook&hl=de_AT&gl=US;https://www.sketchbook.com/
Socrative	3	no	no	no	no	no	IOS and Android	mobile and web-based	https://www.socrative.com/apps/;https://play.google.com/store/apps/details?id=com.socrative.student&hl=de_AT&gl=US;https://apps.apple.com/de/app/socrative-teacher/id477620120
Sprachmemos	1	no	no	yes	no	yes	IOS and Android	mobile	https://play.google.com/store/apps/details?id=com.smartmobitools.voicerecorder&hl=de_AT&gl=US
Sway (Microsoft)	1	no	no* MS account	no	no	no	Browser	web-based	https://apps.microsoft.com/store/detail/sway/9WZDNCRD2G0J?hl=de-de&gl=de;

(continued)

Table A2.

Table A2.

Name of the educational application with no biological/science content	f n = 95	Seal of quality	Costs	In-app purchase	Data protection	Advertisements	Availability	Usability	Webpages and references
TikTok	2	no	no	yes	no	yers	IOS and Android	mobile and web-based	https://www.tiktok.com/; https://play.google.com/store/apps/details?id=com.zhiliaoapp.musically&hl=de_AT&gl=US
Wordwall	1	no	no	no	yes	no	Browser	web-based	https://wordwall.net/de

Source(s): Table by authors