The Use of Eye-tracking in Science Textbook Analysis: A Literature Review

Použití eye-trackingu v analýze učebnic pro přírodovědné předměty: přehledová studie

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Contemporarily available technology has provided researchers with quite an accessible method to see through students' eyes. This offers researchers the chance to re-evaluate teaching materials in terms of their potential function, one that has been largely overlooked. This study presents a literature review drawing on science textbooks that use the eye-tracking method. Relevant journal articles or conference papers indexed in the Web of Science and Scopus databases were selected. From the original 112 papers, 18 were submitted to a thorough analysis after duplicate papers and papers not conforming to the topic were excluded. The studies' characteristics, topics (influence of textbook design on student learning, distribution of attention, textbook effect etc.) and used methods (the device and measurement, additional methods, methodological issues) are included in the review. (Novice) science education researchers, state officers responsible for textbook evaluation, textbook authors and even teachers can profit from this overview, as it clearly indicates the state of the art as well as potential research directions.

Key words:
textbooks, eye-tracking, science education, literature review.

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Aktuálně dostupná technologie poskytla výzkumníkům metodu, jak vidět očima žáků a studentů. To nabízí možnost přehodnotit potenciální funkci výukových materiálů z jejich dosud skrytého úhlu pohledu. V této studii je prezentována literární rešerše výzkumu v oblasti učebnic pro přírodovědné předměty pomocí metody sledování pohybu očí (eye-trackingu). Do studie byly zahrnuty relevantní články z časopisů nebo konferenčních sborníků indexovaných v databázích Web of Science a Scopus. Po odstranění duplicitních záznamů a článků nevyhovujících zkoumanému tématu, bylo z původních 112 prací 18 podrobeno důkladné analýze. Do přehledu publikovaných studií je zahrnuta jejich charakteristika, témata (vliv zpracování učebnice na učení žáků a studentů, rozložení pozornosti žáků a studentů, vliv formátu prezentace učebnice atd.) a použité metody (zařízení a metriky, další metody nebo metodické otázky). Příspěvek ukazuje současný stav zkoumané problematiky a naznačuje potenciální směry výzkumu. Je tak určen výzkumníkům v oblasti přírodovědného vzdělávání (včetně těch začínajících), státním úředníkům odpovědným za hodnocení učebnic, autorům učebnic nebo dokonce učitelům stojícím před výběrem nových učebnic.

Klíčová slova:
učebnice, eye-tracking, přírodovědné vzdělávání, literární rešerše.

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1 Introduction

Research on science textbooks has been growing in recent years (Vojíř & Rusek, 2019), gradually bringing more information about their unique standing in education. One group of research focused on the way textbooks are being perceived or the purpose of their use in education (Červenková, 2010; Lepik et al., 2015; Mullis et al., 2012; Sikorová, 2010; Vojíř & Rusek, 2021). Another group of research focused on the textbook content. Naturally, the ideas, concepts and/or their correctness were evaluated (e.g. Baptista et al., 2016; Gegios et al., 2017; Österlund et al., 2010). Within this group, textbooks' structural components (Rusek et al., 2020) or text-difficulty (e.g. Rusek et al., 2016; Šmídl, 2013) were analysed.

Contemporarily, more and more available new technology enabled, almost literally, researchers to see the books through students' eyes. Former endeavours to provide teachers with a rubric helpful for an informed textbook choice (e.g. Knecht & Weinhofer, 2006; Sikorová, 2007; van den Ham & Heinze, 2018) can thus be enhanced. Eye-tracking cameras or goggles are the cutting-edge gadgets in this respect. They offer a closer look into how textbook components are perceived with the use of more complicated and time-consuming methods, such as the already mentioned text-difficulty based on counting words and distinguishing terms (e.g. Rusek & Vojíř, 2019), categorizing visual components (e.g. Papageorgiou et al., 2017; van Eijck et al., 2011) or assessing visual components in relation to the text (e.g. Slough et al., 2010). Eye-tracking (ET) technology allows for students' eye-movement investigation including e.g. them looking at a textbook page. ET data visualisation includes e.g. scanpaths, or heat maps, the data can also be represented quantitatively, for example time fixation duration, mean fixation duration, fixation

or saccade count. These measures are often detected in specific areas – identified prior to the research or after it according to research results (Lai et al., 2013).

In textbook research, this offers analysis of general layout, its overall ergonomics, different graphical components' fitness and function (Do students use particular textbook components as expected? Are contemporary textbooks useful for students?), or students' independent work with the textbook text (Do they read the entire paragraphs or skip them? Is the text structured enough? Do the included elements guide students when working with the book?). These can be summed up as testing whether the prepared, didactically transformed units suit the target group representatives.

2 Methodology

2.1 Aim

The aim of this review was to map trends in research focused on the use of the eye-tracking method in science textbooks' analysis. For this purpose, a literature review was performed. The following categories commonly used in corresponding reviews (e.g. Lai et al., 2013; Teo et al., 2014; Vojíř & Rusek, 2019) were identified:

- publication characteristics (continent, locality, authors, publication year)
- research characteristics (subject, topic, aim, results)
- methodological information (used device, sample size, reasons for excluding some participants, additional methods).

2.2 Procedure

With respect to paper quality, only papers published in journals and conference proceedings indexed on the Web of Science or SCOPUS databases were chosen for the review.

The search was realised with the use of the following keywords (TS[1] = eyetracking or "eye tracking" OR eye-tracking OR "eye gaze tracking" OR "eye-gaze tracking" OR "eye-based gaze tracking" OR "eyegaze tracking" OR "eye -movement" OR "eye movement" AND TS = textbook*) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article OR Early Access OR Proceedings Paper OR Review), in all WoS core collection databases and the SCOPUS database.

The assortment of articles followed the standard process of screening, identification, and eligibility assessment. Fig. 1 shows PRISMA flow diagram edited according to (Moher et al., 2009), including the numbers of all identified and discarded papers.

First, the papers' records including abstracts were exported to MS Excel. Next, duplications within papers indexed in both databases were eliminated. All records' abstracts were read to evaluate their suitability according to the previous criteria. Only papers corresponding to the review's topic were included for the full-text evaluation. Some papers were excluded based on the use of different methodology than eye-tracking or a different aim than science textbooks (1).

Information regarding the categories defined in the aim above were noted for each of the papers.

3 Results and discussion

A total of 18 studies using eye-tracking in science textbook research were identified. Although it is not as many as studies used ET in education in general (Lai et al., 2013) or in science education (Jarodzka et al., 2017), ET proved to be a promising asset in textbook evaluation too. With the trend of science education research focusing also on textbook research (Vojíř & Rusek, 2019), an increase in this area is expected. With respect to novice researchers in the field, this review then could serve as a basepoint.

3.1 Study characteristics

The number of papers which matched the research criteria does not, yet, follow a clear trend (see Tab. 1). Nevertheless, considering the time of the last database check, there still could be papers published in 2020 not yet indexed on the Web of Science, therefore not found on the search.

Tab. 1: Number of papers published in years

YEAR	1999	2013	2014	2015	2016	2017	2018	2019	2020
PAPERS PUBLISHED	1	1	3	1	3	2	3	3	1

[1]Topic, or abstract or keywords.

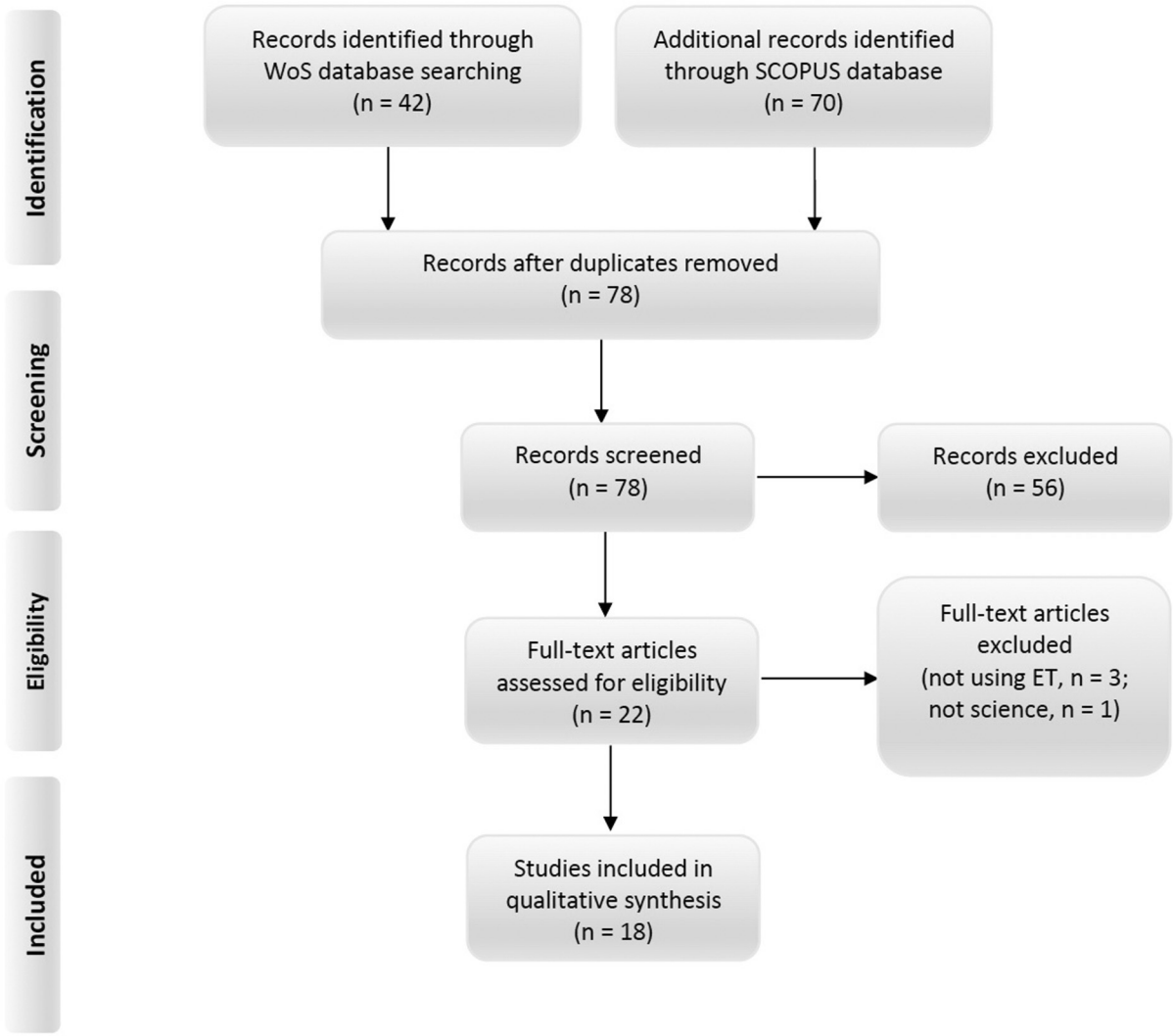

Fig. 1: PRISMA flow diagram describing the papers' selection for the analysis

The gap between the first and second published paper is surprising. Hannus and Hyönä (1999) have shown a very progressive approach to textbook research, which in 1999 already used ET to examine students' work with textbooks. The researchers investigated a still current problem of students' attention distribution between text and images. However, the gap between the first and second paper is surprising. This could be due to the insufficient technology at that time.

Since 2013, science textbook research using eye-tracking has been published every year. Although the search was updated to March 2021, only one research study on textbooks was identified in 2020. Given the trends of previous years, the reason may be due to the coronavirus pandemic and distance learning, in which students (research participants) were not personally present at schools and other institutions (Viner et al., 2020).

As far as its geographical use is concerned, eye-tracking has been used in textbook research mostly in Europe (12 studies), led by Germany (8), followed by the Czech Republic (2) and Finland (2). In Asia, three studies of such focus were identified in Taiwan, Korea and Qatar. In Africa there were two studies - both located in South Africa. There was another done in Australia.

From the level of education's point of view, the research focused on all levels (see Fig. 2). Research mostly focused on participants' comparisons. This included studies comparing student performance on related educational levels, e.g. lower and upper-secondary (Schnotz et al., 2014), but also completely different participant groups, e.g. elementary school students and adults (Jian, 2016; Kaakinen et al., 2015). A specific study in this category is represented by research focused on graduated respondents (Drexler et al., 2019). This study analysed teachers' reading textbooks. The specificity lies in the fact they use textbooks for a different purpose than students.

The studies used samples from 8 to 204 participants. The median was 20. The lower number of participants can be justified by the time-consuming nature of the research, which is often supplemented

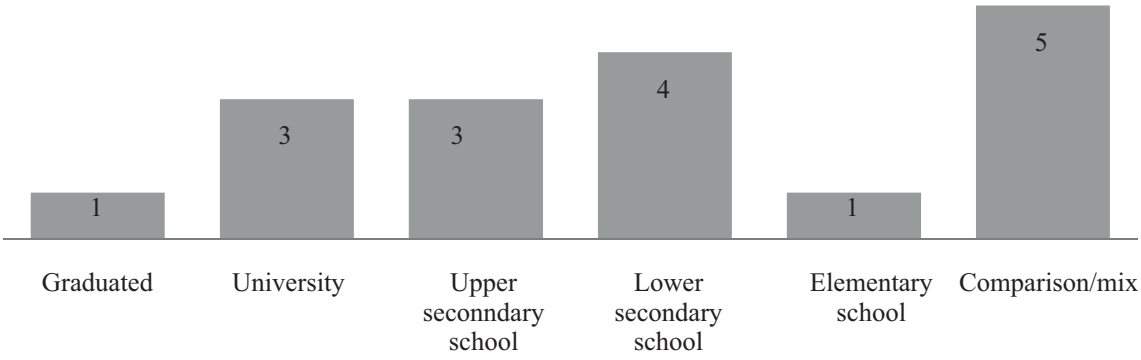

Fig. 2: Number of papers on different school level

by additional methods (e.g. interviews, questionnaires or tests (Gelderblom et al., 1993a; Kaakinen et al., 2015; Lim et al., 2014). On the contrary, studies using data from a higher number of participants work only with the eye-tracker data, analysing them quantitatively only (Schnotz et al., 2014).

Regarding scientific disciplines, eye-tracking for textbook analysis has not been used equally within science education (Fig. 3). The research on physics textbooks showed more focused attention by Ishimaru et al. (2016; 2017). The body of research grouped under the *Science* category included, besides science, also research integrating more school subjects (e.g. biology and geography). The *Other* category included research focused on an unspecified subject or research aimed at a platform or format (e.g. printed or digital) more than on subject-matter (Johnston & Ferguson, 2020; Johnston et al., 2016).

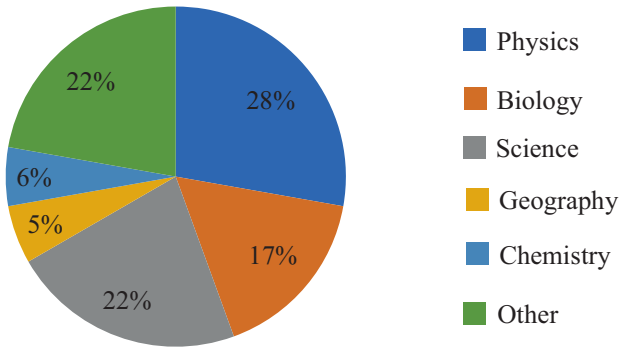

Fig. 3: Shares of studies focused on different science fields

3.2 Topics

The research studies were divided into five topics according to their focus. Analysed studies mostly focused on the *image's presence* (see Fig. 4). The study showed that the distribution of attention to individual parts (image and text) is influenced by many factors, including motivation, students' level (ability, age, type of education) (Hannus & Hyönä, 1999; Ishimaru et al., 2016; Schnotz & Wagner, 2018) and picture location (Drexler et al., 2019).

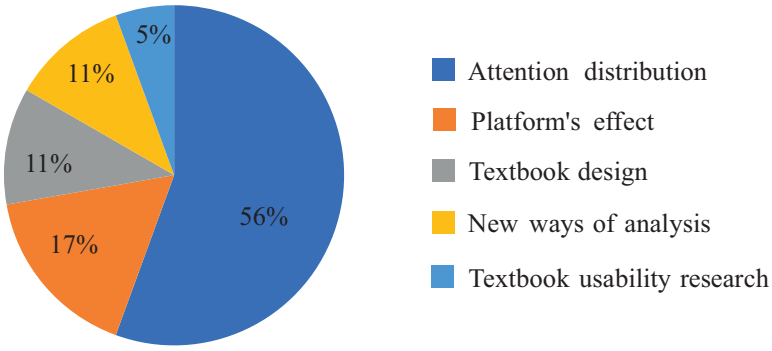

Fig. 4: Distributions of textbook analysis foci

Moreover, eye-tracking data proved to be a valuable source of information about the *effect of a used platform (printed, electronic, tablet, iPad etc.)*. Also, its importance proved the effect of *textbook design* (Kaakinen et al., 2015; Richter & Scheiter, 2019). The review also identified studies focused on *new ways of analysis* (Ishimaru & Dengel, 2017; Ishimaru et al., 2017) and also *usability research* (Gelderblom et al., 2019).

3.2.1 Textbook design

This type of research can bring the interested closer to an ideal textbook design. The influence of text processing has been investigated in chemistry and science textbooks for several years now. Richter and Scheiter (2019) analysed the different reading behaviour according to the presence of *multimedia integration signals* (MIS). They compared MIS +, a chapter which contained colour coding according to the picture, and MIS − chapter, including only text signals, e.g. bold face, headings or labels in the picture. Its use regarding eye-movements and previous knowledge was analysed. The results showed that MIS + improved the performance of students with low prior knowledge, also their visual behaviour changed. These students looked at the pictures earlier and started to read text later when MIS were present, while the high prior knowledge students' outcomes and eye-movements were not affected by MIS. Moreover, these students-perceived cognitive load increased when MIS were present.

Another part of the research focused on textbook design considered the form of chapter titles. In their study on reading tasks' influence on readers' eye-movements, Kaakinen et al. (2015) looked at title design's effect. They compared the difference between the title designed as a question or a statement. The results showed that questions such as "Why are forests important?" maintained readers' coherence better than titles such as "Importance of forests".

When encountering the question-design title, older students and adults went back in the text and formed concepts integrating information from the text. This minor change then seems to improve the reading approach, increasing the texts' educational effect even for inexperienced readers. On the contrary, the question-design forced the youngest pupils (elementary school) to concentrate more on the first visit (measured as their focus on the area of interest) to the text.

3.2.2 Image's presence

Research so far showed that students' use of textbook images was not as apparent as expected. Eye-movement measurement can clarify the difficulties of linking images and text. This was shown in research study on geography textbooks (Behnke, 2014). The heatmaps and scanpaths showed students mostly focused on the text in comparison to images while reading five textbook spreads.

The students' use of images turned out to be influenced by various factors. One of them is *motivation*. Lim et al. (2014) found that more motivated students spent the same amount of time (measured as time fixation duration) on the text and images. On the other hand, the less motivated preferred passive text reading and did not integrate the pictures in them. The reason could be found in their anxiety and demotivation

Another factor affecting students use of the textbook and its effect on students' learning proved to be their *level* – age, the already mentioned ability, or type of education. Research study on 10-year-old students (Hannus & Hyönä, 1999) showed the students with high intellectual ability were more strategic during textbook reading. They spent more time on the text as well as illustrations compared to the low intellectual ability students. Also, they did more back-and forth transitions. The ability to transition between individual textbook parts (text and image) also proved to be important in other studies. Jian (2016) compared adults' and 4th graders' reading behaviours. Whereas adult readers switched between text and illustration often, 4th graders transited in the text or illustration area, but rarely between text and illustrations.

Similar results were obtained in biological textbook research. Hochpöchler et al. (2013) investigated strategies students used while dealing with text and graphics to integrate these two sources of information to answer questions. The strategies were analysed using time fixation duration in text and picture. The results showed the text and images are associated with different student strategies. Texts are used in a coherence-formation strategy. Graphics are used on demand (information-selection strategy). The level of education proved to be an important factor in the use of these components as well. Students from higher track schools looked at the pictures when dealing with more difficult questions. They used the picture as scaffolding. On the other hand, lower track students looked at the picture even for the initial mental model construction but did not use them intensively afterwards. The attention to text and image with students at different levels of education was also studied by Schnotz and Wagner (2018) in biological and geographical textbook research. Senior students gathered more relevant information from pictures more easily (probably due to their higher intelligence. Besides the number of fixations, numbers of saccades

between AOIs were analysed. The senior students switched more often between picture and text. These findings contradict the study in physics textbook by Ishimaru et al. (2016), who found that experts looked at graphics less compared to the novice and intermediate.

These results also showed the importance of an analysed phase. The high-attention parts were almost the same for the novice, intermediates and experts during the reading phase, the solving phase made a difference between these levels.

Moreover, the results revealed another factor that affects textbook text and image processing. It is *"when"*, i.e. particular phases of students' reading focused on different areas. With the students' fixations and saccades (transitions between text, picture and item) analysis, the use of text-image proved to be asymmetrical depending on the reading phase (Schnotz et al., 2014). The percentage of text–picture transitions decreased from the first phase to the last, whereas the percentage of picture–item transitions increased. According to this finding, texts showed to provide conceptual guidance, while images served as external cognitive tools used when needed (e.g. in the question part of the textbook). In their further research study, Schnotz and Wagner (2018) also confirmed that students focused on the image only during the second viewing, where the number of picture fixations was higher than the in-text fixations. Also, the between picture and item transitions were higher than between the text and item. Even in this study, the educational level proved to have an influence, as this characteristics are more valid for more competent learners.

The *location of the image* also showed to be a significant factor. While teachers were reading the textbook, they tended to skip the images. This was probably caused by their educational level, on which the pictures are no longer needed to understand the topic. When the textbook design was atypical (compared to classic textbooks), teachers paid the most attention to the central area of the textbook, even if there was a picture (Drexler et al., 2019).

Research on physics textbooks also showed students read the text from the beginning to the end. However, when there is a picture on the page, they looked at it, no matter where it was placed (Drexler et al., 2018). Students also read the image captions after observing the image (they found out what they had seen right after). This natural strategy can cause misunderstanding and should be included either into their instruction or be treated in the books' design.

As far as particular parts of a chapter are concerned, attention was paid mostly to the chapter's introduction and gradually decreased (Drexler et al., 2019). This calls for the use of special elements. Explaining new subject-matter was proven to have increased readers' attention even in the middle of the chapter (Drexler et al., 2018).

3.2.3 Platform's effect

The platform through which the textbook is presented also plays an important role. Beelders and du Plessis (2018) investigated IT students' reading according to the used presentation medium (Kindle, tablet, iPad, PC, paper). The results showed students read faster when reading on an iPad, which the students also indicated as the most pleasing to use for reading. The results showed paper was the least popular medium in this respect. On the other hand, students had to return to the textbook more on this device. From students' comprehension and concentration's point of view, a PC proved to be the best option, as they did not return to clarify the introduced concepts, as well as the fixations were longer and more numerous. These results, however, need to be read considering the students' specialization. Used to mostly working on a screen, this could have biased the result. For example (Johnston et al., 2016) and later Johnston and Ferguson (2020) found opposing results of students' preferences. For this reason, the topic of a medium needs to be considered with discretion. In studies students' scanpaths were analysed. Results showed students (among others also science students) skimmed and flipped more often and concentrated less on digital textbooks than traditional ones. They also made less notes and underlining than they did in printed versions. Students themselves also confirmed they learned best from a printed text.

3.2.4 Textbook usability research

Another aspect studied using ET in this respect by Gelderblom et al. (2019) was students' habit of working with an e-textbook. They analysed the problems students faced when using an e-textbook. The study compared students who used this textbook for one year with those who used it for the first time. Authors analysed students' gazepaths in a qualitative way to understand problems they faced while working with an e-textbook (scrolling pages, long searching for functionalities, e.g. searching box, etc.). The results showed some problems (e.g. finding the table of contents, creating a summary or highlighting) that arose regardless of the students group. The interviews also revealed the students emphasized the role of teachers in their ability to use the functionalities of these textbooks.

3.2.5 New ways of analysis

The use of eye-tracking in science textbook research, in comparison with the above-mentioned "classics", opened new ways of analysing or using gained information. Some papers included in this review bring a promising future to this method's use. Ishimaru et al. (2017) investigated the possibility of nasal temperature recording and its correlation with student concentration. The results showed potential for this method in students' work with a textbook. However, nose temperature change required a longer time, which could be the limit of its use. To use and process more data together, Ishimaru and Dengel (2017) and Ishimaru et al. (2017) proposed a system which can record natural eye-movements and convert them into valuable data. The data can be used in HyperMind – a system of customizable textbooks. It is built on a system recognizing the students' cognitive state through sensors (including eye-movement monitoring). According to the students' actual attention, the scope and layout of the textbook can change, a static text can be replaced by a video or representations can be changed according to a reader's age. This should improve student motivation and understanding by increasing the time they work with it. This, obviously, is an advantage over static textbooks.

3.3 Used methods

To address the second goal of this study, technical information was gathered to provide readers with an overview of the state of the art.

3.3.1 Eye-tracking device and used measurement

Most of the research used an eye-tracking device mounted on a PC or tablet that allowed for free head movement. The most used devices[2] were Eye Link (6), Tobii (6), SMI (5) and Applied Science Laboratories Model (1). The last one is especially interesting, as it was a model from 1994. In addition, four studies used eye-tracking glasses (Tobii or its combination with SMI). This allowed researchers to work with real (printed) textbooks, which at the same time brings methodological issues (see the chapter below).

Standard eye-tracking metrics were used in the analysed research. The researchers used fixation (count, mean, duration, frequency), saccades (mean, order, count), as well as less common metrics, such as pupil diameter. The Areas of Interest (AOI) were determined for individual stimuli. The quantities mentioned were related to individual AOIs then. Also, other metrics, such as visit count, or time to first visit of a particular AOI, were used. These quantities helped to determine when and to what extent the participants devoted their attention to individual parts of the textbook, therefore when a learning occasion occurred.

3.3.2 Additional methods

Eye-tracking allows where the participant looked to be observed but does not provide any information about why they looked there (Ishimaru & Dengel, 2017). This is why ET studies are often (all but three in this review) supplemented by additional methods. The most common method was a questionnaire (7). These were used to determine students' motivation or preferences. Tests (5) related to reading skills or intelligence (including spatial) were another additional method. Interviews were held in three cases. As mentioned above, a thermal camera was used in one study. Other devices in combination with ET were also used in other research besides textbook research (Cortes et al., 2018).

3.3.3 Methodological issues

The use of eye-tracking in research brings the undeniable benefits of seeing what research participants see. Nevertheless, the method is not universal, and several problems arise when using this method. First, most students with normal to corrected-to-normal vision problems can be tested with satisfactory results. Second, exclusion due to poor or unsuccessful device calibration (Jian, 2016; Kaakinen et al., 2015; Schnotz et al., 2014), quality of recorded data (Johnston & Ferguson, 2020; Richter & Scheiter, 2019) or incomplete or "dishonest" participants' work (Ishimaru et al., 2016) were faced. The number of excluded participants varied from 0 to 19 (med = 2). The authors themselves mentioned the research sample (size or selection) as a limit in their studies (Lim et al., 2014; Schnotz et al., 2014) which shows areas which should be addressed in the future. Third, a problem may occur when textbooks in real conditions (printed) are analysed. For this purpose, eye-tracking glasses are necessary. As experienced by Ishimaru et al. (2016) in a group of younger research participants, unused to the glasses, they often touched them which led to the accuracy loss.

[2]Some studies used multiple devices, so the numbers exceed the number of the analysed research papers.

4 Discussion

Five general topics emerged from the studies included in this review. As one of the selection criteria was the use of eye-tracking, focusing on the visual elements in textbook which are necessary for science education (Eilam & Gilbert, 2014) was natural. The most research attention was paid to the presence of images. Their presence in the text is usually considered beneficial for reader understanding (Carney & Levin, 2002). In addition, teachers were found to choose new textbooks based on their graphical shape (Vojíř & Rusek, 2021) which even increases relevance of this study area. Science disciplines use (graphical) representations of three types: macro-, micro- and symbolic (compare the evolution of the "chemistry triplet" in: Gabel, 1993; Johnstone, 1991; Taber, 2013; Talanquer, 2011) which carry the content/subject-matter. The problems with using images, found in above-mentioned studies, may therefore affect student's learning. In a positive way it offers i.e. showing multiple representations or promote students' learning of abstract topics. On the contrary, it can aggravate learning by increasing the cognitive load, distracting learners or simply (in case of less competent or novice readers) by confusing them. As shown in several studies in this review, motivation, level, quality of such graphics, its location in the text or even time of its appearance were studied. A special guidance could be provided to learners by their teacher in this matter. However, if textbooks were designed in an evidence-based manner, i.e. respecting corresponding research results, the textbook's structural components could be linked in a way which would support young readers to do the necessary transitions. Naturally, e-books or even adaptable e-books (e.g. Ishimaru & Dengel, 2017) could have this potential.

In contrast to the very traditional conception of Czech lower-secondary textbooks (Vojíř & Rusek, 2020) and their almost uniform component content (Rusek et al., 2020), these results could represent valuable evidence when new textbooks are prepared. Analysed studies showed, the use of MIS can improve low-prior knowledge students' performance.

With regards to the known textbooks' role in education in many countries (e.g. Lepik et al., 2015; Mullis et al., 2012; Vojíř & Rusek, 2021), this research seems to be a source of valuable remedy for students' learning results (Richter & Scheiter, 2019).

Apart from the presence of signals, another textbook design principle – the form of title – was studied. The question-designed title proved to enhance participants' understanding leading to a higher amount of back and forth eye-movements. This is usually a more experienced readers' characteristic (Jian & Ko, 2017), however, chances are this could work for other readers too eventually. To illustrate the current state, when Czech chemistry textbooks are evaluated in this criterium, the majority use traditional headings. Only one textbook series (Beneš et al., 1993a, 1993b) used questions in their main chapters' titles. Considering the fact the subchapters – particular lessons' titles are not formulated as questions, the effect found by Kaakinen et al. (2015) does not apply here either. Nonetheless, it can be considered a signal for teachers how to present their lessons goal, even what to write on the board at the beginning of a lesson.

With the increased use of e-books, the effect of a platform or format is currently also a hot research topic. Due to recently increased integration of digital technologies into teaching and households, digital materials gained on their importance (Scully et al., 2021). An attention to this learning materials area was paid even in studies which did not use an eye-tracker (e.g. Ross et al., 2017), nevertheless, eye-tracking data represent a valuable asset providing more detailed information about students' learning behaviour when using a learning material. Gelderblom et al.'s (2019) study showed paper was the least popular medium for students used to working with a computer. With ever developing technology, pandemics-forced shift to online teaching as well as increasingly more available technology such as tablets with stylus pens, e-textbook might soon take over. One way or another, for the time being, students' preferences need to be considered. Research shows most students still prefer traditional, printed textbooks (e.g. Johnston & Ferguson, 2020; Millar & Schrier, 2015).

These information help textbook authors, publishers, education researchers and mainly educators to better understand the functions of textbook together with their adoption. With expected more information from proliferating eye-tracking research, data could help both structure new and use existing textbooks in a way more suited to learners' needs.

5 Summary

In this study, research on science textbooks supported by eye-tracking was reviewed. The number of studies has been rising. It is therefore possible to assume more information to guide a more effective textbook use as well as development will soon be available.

The results showed there are many areas in which ET is used in textbook analysis. Mostly, *distribution of attention between text and image* was investigated. The results showed there are many factors influenc-

ing participants' attention to the text or images. These were: motivation, level, or reading phase. Also, the analysed studies discussed the *textbook design*. Research showed different title or chapter elaboration influenced student work. With respect to the *platform* on which the textbook was presented, students seemed to prefer printed textbooks to the digital, except for IT students used to digital resources. To evaluate the use of an e-book, *usability research* was found. The review also revealed promising innovative *ways of analysis* using ET. This could be used e.g. in designing an "intelligent"/adaptive textbook.

In this study, novice researchers find an overview of the state of the art and can get a head start. A strong message is being delivered to the state offices responsible for textbooks – their development or quality evaluation: there is an emerging, rapidly developing method which could be a gamechanger in this field. It should be supported on a national level so there would be a research group able to assist textbook authors evaluate their new books. Naturally, there are more ways to produce modern textbooks, nevertheless, there has never been such an opportunity to tune textbooks to their users' needs.

The authors of this review are aware of several *limitations*. First, the lower sample of analysed papers included in this study. Review paper samples are usually greater, but a standard methodology was used which resulted with this number of relevant studies. Second, eye-tracking measurements of any other material but textbooks provide similar results as the studies' participants' eye-gaze is not textbook-specific. Nevertheless, as textbooks hold a unique role within education tools, and as they have the potential to be the key agent in the contemporary endeavours to put students in the centre of education by diminishing the teacher's role, well-designed, evidence-based textbooks need to be produced.

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