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# STATISTICAL GRAPHICS IN CZECH TEXTBOOKS: A COMPARATIVE CONTENT ANALYSIS OF TWO PRIMARY-LEVEL EDUCATIONAL AREAS

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**Abstract/Izvleček**
The aim of the article is to introduce an effective structural and functional model for the socialization and development of these children through group work, implemented in out-of-school education institutions (SFM). The study presents a comprehensive model comprising target, substantive, organizational, procedural, result-oriented, and analytical components. It outlines content and methodological support for socialization and development in various areas, such as naturalistic, tourist, local history, artistic, and aesthetic domains. It also highlights the essential spatial-subject, psycho-didactic, and social conditions required for an inclusive educational environment.

**Keywords:**
primary education, textbook analysis, content analysis, statistical graphics, charts.

**Statistična grafika v čeških učbenikih: Primerjalna vsebinska analiza dveh izobraževalnih področij na osnovni ravni**

V članku predstavljamo analizo trenutnega stanja na področju razvijanja spretnosti rabe statistične grafike v osnovnošolskem izobraževanju na Češkem. Raziskava temelji na kvantitativni vsebinski analizi grafičnih prikazov podatkov v učbenikih in delovnih zvezkih, ki se pogosto uporabljajo pri pouku. Ugotovitve razkrivajo pomembne razlike v pogostosti statističnih grafičnih prikazov med različnimi učbeniki ter v oblikah in vrstah uporabljenih statističnih grafičnih prikazov na različnih izobraževalnih področjih.

**Ključne besede:**
osnovnošolsko izobraževanje, analiza učbenikov, analiza vsebine, statistična grafika, diagrami.

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## Introduction

In an increasingly data-driven world, the ability to interpret visual representations of quantitative data and make informed decisions based thereon are becoming crucial skills. Building and strengthening the skills of data visualisation creation and interpretation are becoming a research topic under the umbrella term of data visualisation literacy (DVL, see Börner et al., 2019). This wider interdisciplinary area should build upon insights gathered in, e.g., graph comprehension or statistical literacy research, since common statistical graphics are a substantial part of data visualisation methods. Fostering data visualisation skills from an early age becomes paramount to empowering students as critical thinkers and informed decision-makers. Despite this, research connecting these skills with primary education is still lagging behind the abrupt development in the field. Recent studies in the primary-level area focus on tangibles and gamification together with a constructivist approach (Gäbler et al., 2019; Bae et al., 2023; Johnson et al., 2023). We must also describe the current state of data-visualisation-related instructions in primary education. One way to assess the current state of this instruction is to inquire about textbooks and workbooks used in primary teaching and to focus on statistical graphics. Although some analyses have already been done in the past (e.g. Alper et al., 2017; Shreiner, 2018; Batanero et al., 2018), we still do not have many insights into the use of statistical graphs in primary-level textbooks, and we lack this insight utterly in the context of the Czech educational system.

The analysis of textbooks used in our inquiry is connected to current curricular changes in the Czech educational system, which reflects the state-wide shift to *new informatics*, following the broader European frameworks (Caspersen et al., 2023): putting the stress on computational and algorithmic thinking together with data skills and disseminating those skills from dedicated ICT classes to other areas and topics of education. These revisions are happening in the Czech context at all educational levels up to secondary school, are carried by *The Ministry of Education, Youth and Sports* (MŠMT) and are aligned with the *Strategy for Education Policy of the Czech Republic 2030+* (EACEA, 2022).

*Research focus*

Through our research, we decided to answer the following questions: Q1 – How frequent are statistical graphics (SG) in Czech elementary textbooks in two educational areas? as there were no previous studies that would provide insight into the current state of SG usage in Czech elementary textbooks. We are interested in whether SG are present and how often they can be encountered in textbooks.
Based on local state standards for elementary education and relevant curricular documents, *Mathematics and its application* (MAT) is the educational area *(local framework defines nine core educational areas consisting of educational fields and cross-curricular themes)* that should lead children to educational outcomes regarding basic data visualisation skills. The new informatics shift furthermore advocates blending classes and dissolving the borders between areas. The *Humans and their World* (HTW) educational area is a rational choice for introducing data graphics to young learners, as topics include the broad areas of society, history, natural sciences, or homeland studies. Therefore, we decided to pick this area over other possible ones (like *Language and Language Communication*) and compare them against each other to find out whether this blending is already occurring and how common it is to have SG in an area outside MAT.
Together with the analysis of SG frequency, we are interested in their role in textbooks and workbooks and whether these roles differ significantly in selected educational areas: Q2 – Do the graph functions differ in the MAT and HTW areas? We are also interested in the types of SG used in Czech textbooks and whether these types differ in HTW and MAT: Q3 – What are the types of charts presented, and how do the types differ in the HTW and MAT areas? In both cases, the null hypothesis (H0) postulates that there is no significant relationship or difference between the variables under investigation.

## Research Methodology

*General Research Background*

Textbooks are still considered an essential part of the classroom process (Mullis et al., 2012; Son and Diletti, 2017) and often play a dominant role in instruction at the primary education level (Stará et al., 2017). Textbook analysis has been widely used, with some researchers focusing on the broad category of visuals (Vojíř and Rusek, 2019). Mapping textbooks through content analysis can yield vital insights; hence, we conducted a content analysis of Czech primary-level textbooks selected from the MAT and HTW educational areas.

SG-focused content analysis is still uncommon. Some previous content analyses focused on diagrammatic representations (Liu and Khine, 2016), a different part of the visual communications field, or on specific benchmarks, like gender balance in STEM visuals (Kerkhoven et al., 2016). The more expansive approach of focusing on visuals in general can be limited its provision of insight into the use of statistical graphics, as categorisation and classification can get cumbersome with many types of visuals. An insightful study conducted by Guo et al. (2018) classified graphs as one of the coded groups in their broader classification but included Venn diagrams or pyramid charts under this category.

A few narrowly focused content analyses show that graphs and other data visualisations are present in educational materials (Alper et al., 2017; Shreiner, 2018), and K-12 students in some geographical areas do encounter graphically represented data. The most progressive content analysis of SG in primary education was part of a broader work by Alper et al. (2017) and Chevalier et al. (2018), who focused on a variety of visually represented data, primarily on how abstraction levels in graphic data displays are progressively delivered through classes. They analysed 2600 visualisations, including pictographs and other simple graphic representations of data, but they did not focus on fully developed statistical graphics. Since we have already explored the aspect of progress in visual representation of data in Czech elementary MAT textbooks, in this study, we focus on comparing two learning areas, focusing solely on fully developed statistical graphs (SG).

*Sample*

For our content analysis, we chose primary-level textbooks, together with workbooks, in the Czech language, intended for the MAT and HTW areas. Only textbooks with a valid note of approval granted by *MŠMT* at the time of the analysis were selected and analysed. This note of approval is a significant marker for the frequency of textbook usage, as only textbooks with the note can be acquired by the school with state financial support.

Textbooks and series from twelve different publishers were also chosen based on consultation with professional subject librarians from *The National Pedagogical Museum and Library of J. A. Comenius*. A total of 182 textbooks were analysed, totalling 2,3452 pages (see Table 1 for more descriptive statistics), a sample covering both educational areas more than amply.

Table 1. Number of textbooks (TB) and pages (PG) analysed in our sample by area and publisher.

| | HTW | | MAT | | Total | |
|---|---|---|---|---|---|---|
| *Publisher* | TB | PG | TB | PG | TB | PG |
| ALTER | 34 | 1495 | 20 | 1165 | 54 | 2660 |
| DIDAKTIS | 11 | 841 | 15 | 1209 | 26 | 2050 |
| FORTUNA | 2 | 94 | 0 | 0 | 2 | 94 |
| FRAUS | 30 | 1874 | 28 | 1919 | 58 | 3793 |
| H-EDU | 3 | 160 | 0 | 0 | 3 | 160 |
| H-MAT | 0 | 0 | 15 | 776 | 15 | 776 |
| Nová škola | 37 | 2226 | 29 | 1620 | 66 | 3846 |
| NŠ DUHA | 18 | 1057 | 20 | 1117 | 38 | 2174 |
| Prodos | 14 | 794 | 20 | 1259 | 34 | 2053 |
| Prometheus | 0 | 0 | 17 | 1544 | 17 | 1544 |
| SPN | 16 | 1207 | 14 | 1075 | 30 | 2282 |
| TAKTIK | 17 | 1032 | 17 | 988 | 34 | 2020 |
| Total | 182 | 10780 | 195 | 12672 | 377 | 23452 |

*Procedures and analysis*

As already stated, we are focusing on fully developed statistical graphs – visual units that work as graphic devices as defined by Roberts (Roberts et al., 2013): “Graphical devices that illustrate the relationship between two or more variables using points, lines, or differentiated parts of a whole (e.g., pie graph, line graph, bar graph)”, i.e. they are fully developed SG with all the components that constitute it. The presentation of such a graph can take various forms in textbooks; therefore, as an analytical unit, we chose an exercise (a visually delimited part of a textbook content) that uses fully developed statistical graphics.

The rules and codebooks for determining the activity type and graph type were stabilised and discussed. A small exploratory sample of textbooks from both areas was selected and pre-analysed with a fellow reviewer to validate and clarify ambiguous units. This pre-inquiry also informed the *a priori* code book for types of tasks and types of graphs. There is no single referential classification of graph types; therefore, we decided to make use of part of the classification we created for our previous research (Marek and Maněnová, 2022), which we based on published content analysis and major reference guides from the area: Harris (1999) and Schwabish (Schwabish, 2021). The simplified *a priori* classification uses four main categories based on the main visual elements, using different visual variables: bar, line, point and pie graphs. During the coding, limited units utilising statistical maps were identified, and this category was included *emergently*. In the case of the activity types, we identified three main *a priori* groups: units focused on *creating* SG, *reading* SG, and those *combining* both. This classification proved to be sufficient for our sample and our goals. The statistical analysis was conducted with IBM SPSS Statistics software.

## Results

### *Frequency of statistical graphics*

We identified 579 analytical units in our sample, averaging 2.47 exercises with statistical graphics per 100 textbook pages. Two specific publishers were excluded from further analysis as their textbooks and workbooks did not contain a single analytical unit (FORTUNA and H-EDU, totalling five textbooks focused on primary-level financial literacy and ICT). Frequency per 100 pages can be seen in Table 2, while absolute values divided by year and publisher appear in Table 3.

Table 2. Count of analytical units by publisher and area; with per 100-page rates (sorted in descending order by total rate).

| | HTW | | MAT | | Total | |
|---|---|---|---|---|---|---|
| Publisher | Units | Per 100 p. | Units | Per 100 p. | Units | Per 100 p. |
| TAKTIK | 14 | 1.357 | 83 | 8.401 | 97 | 4.802 |
| Nová škola | 32 | 1.438 | 115 | 7.099 | 147 | 3.822 |
| Prometheus | 0 | 0.000 | 46 | 2.979 | 46 | 2.979 |
| H-MAT | 0 | 0.000 | 21 | 2.706 | 21 | 2.706 |
| Prodos | 2 | 0.252 | 43 | 3.415 | 45 | 2.192 |
| FRAUS | 41 | 2.188 | 41 | 2.137 | 82 | 2.162 |
| ALTER | 7 | 0.468 | 46 | 3.948 | 53 | 1.992 |
| DIDAKTIS | 6 | 0.713 | 32 | 2.647 | 38 | 1.854 |
| NŠ DUHA | 4 | 0.378 | 23 | 2.059 | 27 | 1.242 |
| SPN | 3 | 0.249 | 20 | 1.860 | 23 | 1.008 |
| Total | 109 | 1.011 | 470 | 3.709 | 579 | 2.469 |

*Types of tasks and differences between areas*

Types of tasks were counted based on the mentioned *a priori* codebook. A chi-square test was performed and demonstrated a significant difference associated with the type of activity (reading/writing/combined) between education areas (MAT/HTW), x2(2, N = 579) = 25, 2466, p < .001, with a medium effect size (Cramer's V = .209). To find out which cells have a significant effect, we further performed a post hoc test based on the work of Beasley and Schumacker (1995), and García-Pérez and Núñez-Antón (2003); i.e. we analysed standardised residuals and calculated individual chi-squared values and evaluated their p-values (see Table 3).
After the Bonferroni correction, the significance level was set to 0.05/6, i.e., 0.0083. Results show significantly (p <.00001) higher representation of reading type tasks in HTW (80.73% of all tasks in HTW) than in MAT, and a significantly (p < .00001) greater proportion of creative tasks being combined with reading tasks in MAT (20.43% of all tasks in MAT) than in HTW.

Table 3. Counts and expected counts by type of activity and educational area.

| Type | | HTW | MAT | Total |
|---|---|---|---|---|
| Reading | Count | 88 | 270 | 358 |
| | Expected count | 67.40 | 290.60 | |
| | Adjusted residual | 4.51 | -4.51 | |
| | % within column | 80.734 | 57.447 | 61.831 |
| Combined | Count | 3 | 96 | 99 |
| | Expected count | 18.64 | 80.36 | |
| | Adjusted residual | -4.42 | 4.42 | |
| | % within column | 2.752 | 20.426 | 17.098 |
| Creating | Count | 18 | 104 | 122 |
| | Expected count | 22.97 | 99.03 | |
| | Adjusted residual | -1.29 | 1.29 | |
| | % within column | 16.514 | 22.128 | 21.071 |

*Types of SG and differences between areas*

For further analysis, we excluded analytical units that did not have a specified graph form in their instructions (e.g., "*draw a graph from the values in the table*", while the type of SG was not restricted in the task). We also excluded maps, as there were only five cartograms in our sample, and pooling would not provide relevant results.
The chi-square test demonstrated a significant difference associated with the type of

chart (bar/line/pie/point) between education areas (MAT/HTW), x2(3, N = 533) = 90,072, p < .001, with a large effect size (Cramer's V = .411). An identical post hoc test was performed here as with the type of task. The significance level after the Bonferroni correction was set at 0.05/8, i.e., 0.00625. Statistically significant cells include all except line graphs, i.e., significant differences in graph types are shown for both bar and pie and point graphs (see Table 4).

Results show significantly (p<.00001) higher representation of bar charts in MAT (62.53% of all problems in MAT). Compared to expected values, bar charts are surprisingly scarce in HTW textbooks. We also measured a significant (p <.00001) relationship between HTW and MAT regarding pie graphs: greater than expected values of representation occur for pie graphs in HTW (56.12% of all units in HTW contain pie graphs, while in MAT, only 13.33% of the SG in the units are pie graphs). Results also show a significantly (p =.00221) higher representation of point graphs in MAT.

Table 4. Counts and expected counts by types of SG and educational areas.

| Type | | HTW | MAT | Total |
|---|---|---|---|---|
| Bar | Count | 35 | 272 | 307 |
| | Expected count | 56.45 | 250.55 | |
| | Adjusted residual | -4.85 | 4.85 | |
| | % within column | 35.71 | 62.53 | 57.60 |
| Line | Count | 7 | 58 | 65 |
| | Expected count | 11.95 | 53.05 | |
| | Adjusted residual | -1.69 | 1.69 | |
| | % within column | 7.14 | 13.33 | 12.20 |
| Pie | Count | 55 | 58 | 113 |
| | Expected count | 20.78 | 92.22 | |
| | Adjusted residual | 9.36 | -9.36 | |
| | % within column | 56.12 | 13.33 | 21.20 |
| Point | Count | 1 | 47 | 48 |
| | Expected count | 8.83 | 39.17 | |
| | Adjusted residual | -3.06 | 3.06 | |
| | % within column | 1.02 | 10.80 | 9.00 |

## Discussion

Fully developed statistical graphics are present in Czech MAT and HTW textbooks. Their frequency levels vary between publishers and may depend, for example, on the author's approach to statistical graphics. There were textbooks with zero SG on one side of the spectrum and textbooks averaging more than eight exercises utilising

SG per 100 pages. Even though year one textbooks work with graphic representations of data (Alper et al., 2017), there were no fully developed SG on this level. We also encountered some distinct cases, like the publisher *Nová škola*, which used a specific graphic device early on (year 2) to facilitate the learning process of adding and subtracting in MAT. This graphic display is a fully developed statistical graph by our definition, even though the publisher explicitly does not address this display as a graph in the text. Content analysis is unable to provide answers to whether the authors chose this graphic device intentionally to support data visualisation skills.

This is one of the limits of content analysis inquiry. There are empirical limitations of textbook research, as already pinpointed by Weinbrenner (1992). We also cannot describe the actual usage of the materials and provided exercises (units) in everyday classroom settings, i.e. we now know that SG are present in Czech elementary textbooks, and that their frequency varies. However, for example, the fact that a specific school uses textbooks by a low-frequency publisher does not necessarily mean that we should expect the DVL level of its students to be lower, since many other variables influence pupil literacy. We still consider this research method valuable and insightful, as it can provide a basis for later researchers seeking to understand the classroom realities of building and nurturing skills related to SG.

The data obtained in this study supported the rejection of the null hypotheses. Interestingly, results show a significantly greater representation of creating tasks combined with reading tasks in MAT (20.43% of all tasks in MAT are *combined*) than in the HTW area. Still, more than 22% of units in MAT are strictly *creating* tasks. While *combined* units may represent the process of using a statistical graphic as a tool to deal with a task and subsequently to answer an entry question, we noticed that many creating-only tasks were utilised without further inquiry, i.e., within a task like "*create a graph from a table*", without subsequent use of the created chart to answer questions or find a solution for a contextual problem that was lacking. The types of grounding for the tasks in the broader context and the realities of using SG as a problem-solving tool will require further qualitative research. The same applies to reading tasks, which are significantly more common in the HTW area. This may also be related to the lack of perception of SG as a practical tool.

This insight may also be connected to pie graphs being more common in the HTW area than in MAT. Pie graphs are among the most common forms for visualising proportions (Siirtola, 2019), even though they have long been the subject of professional and emotional debates on the legitimacy of their use (Spence, 2005).

The fact that most graphs (56.12%) in HTW are pie graphs shows that the authors may be inclined to this aesthetically pleasing form. The higher representation of point graphs in MAT could be due to their use in exercises related to coordinate systems ("*record the coordinates for the point X[3,5]*", etc.). There, while they may often not be directly intended as statistical graphics, by definition, they are fully developed scatter plots, a subset of the *point* graph category in our classification.

## Conclusions

The study revealed varying frequencies of SG in Czech MAT and HTW textbooks used in primary education. Some textbooks lack such displays, while others incorporate them more frequently. The study highlights differences in the types of tasks and forms between the MAT and HTW areas, suggesting varied perceptions of the efficacy of statistical graphics in building and strengthening data visualisation skills. The results offer a foundation for informed investigation into the practical application of SG and its role as a problem-solving tool in elementary teaching and learning contexts.

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