

# Exploring Geolocation Data: An Inquiry-based Methodology Used in Lower Secondary Education

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**Keywords:** Inquiry-based Learning, Mobile Technology, Computer Science Education, Geolocation Data.

**Abstract:** The presented research study is focused on building conceptual knowledge of pupils in the field of data representation and tools for their processing using the inquiry-based methodology (the 5E model was applied). We have chosen geolocation data as a less traditional type of data, which also provides an opportunity for a non-traditional form of teaching computer science outdoors using mobile technology. Pupils' task is to determine suitable tools for processing geolocation data. They analyze a GPX file's contents and formulate questions that can be answered from the available data. During the outdoor phase of the learning scenario, pupils produce an original GPS drawing and share it in a common digital map. Data collected from teachers who implemented the proposed methodology in several primary schools confirmed that our methodology based on the IBL principles was successful in achieving educational goals at higher levels of Bloom's taxonomy. The teachers were also confirming that combining the inquiry approach with using mobile technology stimulates pupils' interest in the subject of teaching significantly.


## 1 INTRODUCTION


Typically, computer science is taught in a computer laboratory where the individual work of pupils prevail. Pupils process data they are creating themselves (texts, images), have been given by a teacher or downloaded from the internet. Sometimes, data are generated by a program or pupils get it using a specific hardware (e. g. scanner, camera, microphone or some other sensor). When processing data of a certain type, pupils usually work with a specific software tool and solve tasks given by their teachers. If software is new (unknown) to pupils, they work according to their teacher's instructions.

In this paper, we focus on solving the problem of building conceptual knowledge of pupils in the field of data representation and tools for their processing at higher levels of Bloom's taxonomy (BT) using the inquiry-based (IB) methodology. Conceptual knowledge is one of the 4 categories of the revised Bloom's taxonomy knowledge dimension and comprises the interrelationships among the basic elements within a larger structure that enable them to function together. The 3 other categories include the

factual, procedural, and metacognitive knowledge (Krathwohl, 2002). We have chosen geolocation data as a less traditional type of data, which also provides an opportunity for a non-traditional form of teaching computer science outdoors using mobile technology.

The well-designed inquiry-based learning (IBL) enhances learners' curiosity and motivation, mediates deeper understanding, and fosters critical thinking. Through IBL activities, pupils are taught to think and act like the scientists do. The meta-analysis of many empirical studies presented in (Lazonder and Harmsen, 2016) points out that whenever learners act like scientists, their teacher should provide them with adequate guidance. The authors of the meta-analysis found out, that the learners who were given some kind of guidance acted more skillfully during the task, were more successful in obtaining relevant information from their investigational practices and scored higher on final tests. As we agree on the beneficial implications of the constructivist learning and teaching strategies, we have decided to apply the 5E instructional model of IBL (Bybee et al., 2006) in our methodology.

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Tkáčová, Šnajder and Guniš (2019) pursued a research study on teachers' perception, attitudes, experiences, misconceptions, and barriers to IB teaching of computer science. Though the IB approach is still considered rather innovative in Slovak schools, this study confirmed that many computer science teachers in primary and secondary schools are willing to apply IBL principles in their teaching. The teachers seek for additional training and prefer using ready-made methodologies to overcome their lack of experience. They found the IBL appropriate mainly for topics concerned with programming or data processing.

One project of teaching the basics of programming in Scratch enriched by IBL elements was described in (Vaníček, 2015). The author also suggests that IBL is a response to the improper teaching methods used in primary and secondary schools that are often based on mere reproduction of knowledge, on instruction and tutorials not resulting in deeper comprehension nor development of thinking skills.

Since mobile devices have become available in schools, many educational researchers are focusing on finding effective ways of using them in the curriculum. Lovászová, Cápav and Michaličková (2016) presented the best practices for using mobile technology in teaching computer science. The main reasons for considering mobile learning scenarios more frequently include:

- they can facilitate collaborative learning, creative projects and authentic learning activities not bound to the indoor classroom environment,
- they have potential to contribute to the intrinsic motivation of pupils (because of their personal features),
- they can facilitate both, the active construction of knowledge and development of new skills.

Besides using mobile devices as a versatile learning tool or to enhance the interactivity and the collaborative aspect of computer science lessons, pupils can also program their own mobile applications as well as take the mobile devices outdoors to experience location-based games or collect some specific data necessary for a project.

Yakar et al. (2020) explain how mobile technology is being adopted in learning nowadays and how it helps learners and educators with the key aspects of constructivism such as interaction, collaboration, and authentic experience. These create an informal atmosphere where social and cognitive

constructivism can be implemented more easily to enhance the quality of formal lessons.

In (Suárez et al., 2018), a systematic review of using mobile technology in IBL was conducted. The study aimed at examining to what extent the use of mobile technology for IBL supports and limits learners' agency. The authors developed an analytical framework helpful for designing effective mobile activities that balance learners' agency with mobile technology. Their classification includes 12 types of mobile activities derived from the direct instruction, access to content, data collection, peer-to-peer interaction and contextual support type of mobile activities. Furthermore, they identified 6 dimensions for learners' agency (control over goals, over content, over actions, over strategies, and options for reflection and monitoring). The way the mobile technology is integrated within the proposed IB methodology corresponds with their recommendations. In our methodology, pupils are given an opportunity to explore geolocation data in a computer laboratory using multiple software tools first. But subsequently, pupils are involved into a collaborative data-collection activity based on using tablets or smartphones. Pupils are free to set their own goal (come up with an original idea for a GPS drawing) and plan the procedure of achieving it. Throughout the outdoor phase as well as after visualizing the collected data (the GPS drawings), pupils are able to reflect their results or refine their strategy for solving the problem if necessary.

## 2 EXPLORING GEOLOCATION DATA WITH PUPILS

At the heart of inquiry-centered learning is the inquiry question. Thinking is driven by questions, not answers. If pupils are engaged in inquiry, they are expected to construct their own meaningful questions, refine, and improve their questions, strategize on designing and producing responses to their questions (Chu et al., 2021). In our methodology, pupils' task is to determine suitable tools for processing geolocation data. They analyze a GPX file's contents and formulate questions that can be answered from the available data.

After learning about GPX files and their processing using a digital map, pupils are asked to use their GPS-enabled mobile devices to record geolocation data while moving outdoors actively. They are encouraged to express their creativity to produce original GPS drawings.

Finally, pupils present their GPS drawings in a shared map, creating one common product because of collaborative work of the whole group.

## 2.1 Design of the Inquiry-based Methodology

The suggested methodology is meant for pupils in 7<sup>th</sup> or 8<sup>th</sup> grade (in Slovakia these are 12-14 years old pupils). It directly follows a preceding one that is focused on principles of satellite navigation. We assume that pupils are already familiar with concept of geographical coordinates, and they have used their mobile devices to navigate to multiple places recently.

The learning activities are planned for a period of 90 minutes (2 lessons). Pupils work in pairs to promote collaboration and communication while solving problems. Worksheets are used as an aid for structuring pupils' ideas.

To process the recorded routes, teachers have to prepare a shared digital map with layers for each pair of pupils. Sample GPX files with geolocation data are attached to this methodology too. They are selected on purpose to demonstrate different types of routes. Teachers can also prepare their own files, e. g. from around the school area. However, routes must be recorded in the field and exported to GPX files, not edited using a map software.

In following subsections, key information about each of the 5 consecutive phases of the 5E model is summarized.

### 2.1.1 Engaging

At the very beginning, the main goal is to generate interest of the topic, drawing on prior knowledge and experience of pupils. Teacher raises these questions:

- What types of files do you know?
- What information these files contain?
- What software would you use to view and process them?

The answers of pupils are written on a board into a 3-column table (Table 1). Pupils use their worksheets to record all the acceptable answers. Alternatively, two lists of file types and applications could be made by pupils. File types are then assigned to applications that are applicable for viewing or processing them.

Table 1: Example of the first activity's solution.

file type	contents	application
jpg	picture	Paint
sb3	programming project	Scratch
docx	text document	MS Word
xlsx	table	MS Excel
pptx	presentation	MS PowerPoint
html	web page	Google Chrome
wav	sound	Windows Media Player

### 2.1.2 Exploring

The lesson continues by posing a problem. Each pair of pupils gets a different GPX file to explore. Teacher acts as a facilitator observing pupils' interactions and asks the following inquiry-oriented questions:

- What software can we use for viewing the contents of GPX files?
- What kind of data are saved in GPX files?
- What questions can be answered from analyzing these data?

During the previous activity, pupils have recalled their knowledge of various information types, their digital representations as well as tools for their processing. They have realized that different file types are processed by different applications and applications can manage to process or view the contents of various file types. Therefore, when examining a GPX file, they may experiment with opening it in multiple different applications to discover the most appropriate one. The expected findings include:

- A GPX file is a text file.
- It can be opened in a text editor, e. g. Notepad, MS Word, in a web browser, e. g. Mozilla Firefox, Google Chrome, in a spreadsheet editor, e. g. MS Excel (in this case, data need to be converted).

After viewing the file, pupils analyze its content putting down notes in their worksheets. They should be able to identify the time and geographical coordinates (latitude, longitude), with which they have experience from previous lessons. The file also contains elevation data. The numeric data is tagged. Pupils should recognize their meaning (TIME = time, LAT = latitude, LON = longitude, ELE = elevation, TRKPT = track point) either from their English knowledge or the numerical values themselves. They should also note the repetitive structure of data and hypothesize that it is a record of geographical places in a time sequence (times increase), possibly a record of one's movement while walking or running.

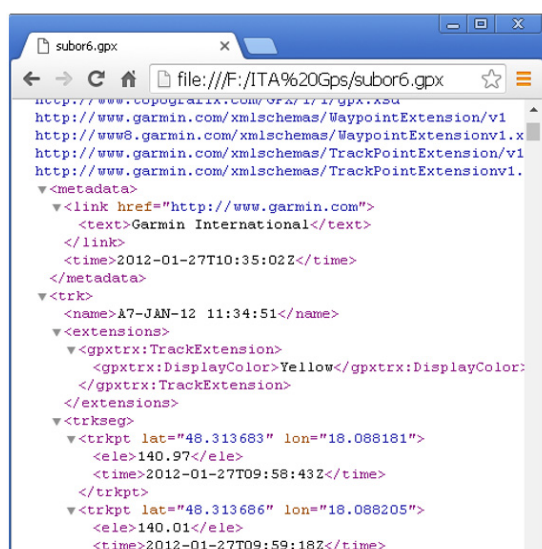


Figure 1: Using a web browser for viewing contents of a GPX file.

Next, teacher asks pupils to formulate questions that can be answered from data contained in their GPX file. Discussion should result in a list of relevant questions, e. g.:

- Where is the route located?
- When was the route recorded?
- What is the length of the route?
- How long did the recording last?
- What was the maximum, minimum altitude, what about the altitude difference?
- What was the speed of movement?

### 2.1.3 Explaining

Guided by teacher, pupils try to explain their observations and findings in their own words. Teacher is responsible for connecting pupils' informal language with formulations based on using the proper terminology.

Next, pupils have to suggest the way of obtaining necessary information from data. Some numerical data could be processed using a spreadsheet editor (e. g. to calculate the record's duration or determine the minimum and maximum altitudes). However, we need a digital map to process geographic coordinates.

In this phase, the learning activity is focused on processing data files using the Google Maps application. Pupils need to find out their route's location and give it a concise title. Teacher provides pupils with link to a shared map comprising dedicated layers to use. Pupils import their file into their individual layer. Task of renaming a route according to its location and nature develops critical thinking –

the ability to interpret data. In every case, the route's description also includes basic statistics necessary for answering questions stated during the previous phase. Pupils can complete descriptions of their routes by adding some explaining text or even an image.

Then, pupils present their solutions to each other in a shared map. They will get examples of different types of routes, e. g.:

- long hikes in nature with a large elevation difference,
- shorter routes mapping objects in the urban environment,
- routes creating a meaningful image in a structured urban environment,
- routes on free space representing inscriptions etc.

Teacher encourages pupils to discuss the use of GPS tracking in everyday life, e. g.:

- for recording sports performances (tourists, runners, cyclists),
- to record routes traveled by car (business trips, holidays),
- for map creation purposes (hiking trails, roads, land properties),
- for creating interesting images, works of art (graphics, advertisements).

### 2.1.4 Extending/Elaborating

After working with GPX files and using a shared Google map, we continue with the outdoor part of the methodology. Pupils should apply the acquired knowledge of GPX files and digital map skills to their own data in a mini project: They will design their own image, which they will record outside using a mobile device with GPS and publish it in a shared digital map. They still work in pairs. Each pair of pupils has a tablet or a smartphone with Locus Map Free application installed (or some other application providing similar functionalities depending on the targeted mobile platform).

The outdoor part of the route recording activity should take approximately 25-30 minutes. A school playground is usually a satisfactory (as for its size) and safe drawing space. To get nice, aesthetic results, we recommend pupils drawing simple, single-stroke line images (e. g. geometric shapes and their combinations), outlines of buildings or large inscriptions (written font is more suitable than printed one).

After returning to school, pupils can view results of their work first on a mobile device. Then, they transfer the GPX file they have just produced to a

computer, either wirelessly or by cable. The final task is to import their GPX file into a common map, giving their drawing a proper name.

### 2.1.5 Evaluating

At the end, pupils evaluate each other's drawings voting for the most beautiful picture (originality and aesthetics are considered). The teacher can also project some additional examples of GPS drawings made by professional GPS artists or other groups of pupils. The experience of being involved in the GPS drawing activity is reflected by pupils and all the acquired knowledge is summarized. Pupils fill in the self-assessment cards included in their worksheets. This helps them with reviewing the contents of lessons as well as systematizing of the curriculum.

## 3 RESEARCH STUDY

The proposed methodology was developed within the national project IT Academy which was aimed at designing and implementing innovations into the science and technical education with special focus on teaching computer science to foster pupils' motivation for pursuing career in IT sector. The methodology was implemented by teachers from several Slovak schools. In our research study, two research questions (RQ) were posed:

*RQ1: What is the knowledge level of lower secondary pupils as for the field of data representation and tools for their processing?*

*RQ2: How is the proposed methodology beneficial for developing the conceptual knowledge at higher levels of BT?*

### 3.1 Methods

The research involved 30 teachers from 30 Slovak primary schools. They applied the methodology in the 7th or 8th grade classes once or repeatedly with different pupils in the school years 2018/2019 and 2019/2020. We provided teachers with detailed lesson plans, supplementary methodical and technical instructions, worksheets, and data files. After the first year of verification, we conducted interventions based on feedback from teachers. Some minor changes in learning materials for pupils were made (re-formulating of the assignments and updating manual of the recommended mobile application). The methodical instructions for teachers were extended to explain some issues identified from the feedback data (some instructions or tasks for pupils were

misunderstood by teachers). Also, a list of documented pupils' misconceptions was added.

For research purposes, teachers provided us with data of two types:

1. Their pupils' products - completed worksheets as well as geolocation data pupils recorded with mobile devices and subsequently processed in Google Maps.

2. Written structured reflections, in which teachers commented on goals of the learning activities, the extent to which they were met, the content's complexity, the teaching forms, methods, tools and didactic technologies applied.

We analysed the obtained data qualitatively. Pupils' solutions in worksheets were evaluated and categorized to identify the level of knowledge, most common mistakes, and misconceptions. Teachers' reflections were also analysed in depth to better understand the context in which pupils were working while solving problems. We were interested in abstracting teachers' essential views on the proposed methodology as for its key attributes (IBL principles, learning outdoors, using mobile technology).

### 3.2 Results

The results of data analysis from worksheets are presented according to solutions of tasks in the individual phases of IBL:

*Task 1 (Engaging): Name various types of files. What kind of information do they contain? What application do we need to view and process them?*

There were 41 different answers found in worksheets that we have categorized in 12 categories. In Figure 2, the frequencies of responses are visualized.

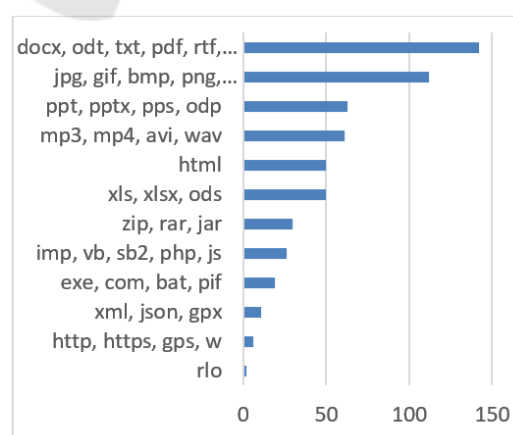


Figure 2: The frequencies of file types stated by pupils.

Most often, pupils mentioned the files containing text, image or a computer presentation, audio/video, tables, compressed files, programming codes, executable or some other system data files, structured data, special files having an educational content as well as various incorrect answers (http, https, gps, w).

In most of the answers (80%), the information kind and the related applications were identified correctly. Though, also some mistakes were noticed:

- Pupils did not distinguish between the contents of a file and the tool for processing it. They stated e.g., that the file “xls” contains “spreadsheet” and the processing tool is “Excel”, “doc” contains “text editor” and is processed by “OpenOffice.org”.
- Pupils stated http, https (mistaken with html) as the file type.
- Pupils identified applications with company names: Adobe (instead of Adobe Reader), Google (instead of Google Chrome), Microsoft (instead of MS Word).
- Pupils confused operating system and applications: they presented Android, Windows, iOS, Linux as applications for word processing or websites.

Most teachers found the difficulty of this task appropriate to prior knowledge of pupils (“In 7th grade, pupils have already experience with various data files.”). However, for some teachers, the activity was difficult, because “pupils do not know lots of files and are not capable of naming it properly”. According to many teachers, pupils did not understand the assignment at first. But after giving a specific example (e. g. a text file having the txt extension contains text data and a text editor, such as Notepad, is applicable for viewing it), they were ready to respond on their own (“First, pupils were a bit confused, but after a short reminding, they continued further without major problems.”).

*Task 2 (Exploring): Find out the following: What software do we need for viewing data in GPX files? What data are contained in GPS files? What information can we get from the data?*

The purpose of this task was to find out what data the unknown file type contains. To do this, pupils should first find out what application they can use to view the contents of the file. In their worksheets, pupils gave more options. They suggested a text editor, a spreadsheet processor, a web browser, even some map software was mentioned (Google Earth, Google Maps, MapSource, OpenStreet Maps). The incorrect answers comprised applications that are not applicable for viewing GPX files at all, e. g. a graphic

editor (Paint) or pupils stated something other than an application (e. g. GPS, XML).

The second part of the task was focused on higher cognitive processes: to analyse the text and abstract essential data (time, latitude, longitude, altitude), recognize the pattern in the data structure (route as a sequence of points on Earth arranged in time), and formulate problems (questions) which can be solved using the data in the file.

The complexity of the task depended on application pupils were trying to use for viewing the GPX file’s contents. In a simple text editor, the text is not structured so the task is more difficult. More sophisticated editors do hide markup language tags that describe the meaning of the data. The most obvious is the display in a web browser – structured with visible tags. In the unstructured view of the file, pupils noticed an irrelevant link to the page of the application that recorded the route, and “this distracted them from the essentials, and they didn’t have enough time to examine their GPX file well.”

In the last part of the task, pupils formulated many good questions: “Where does the route start? Where does it end? In which state / city is the route? How long did it take? What was the average speed? What was the lowest and highest altitude? What is the overall ascent/descent? What color will the route be marked?” The most common mistakes of pupils were:

- Pupils reported that their file contained data that was not in it. It was primarily the information that could be calculated from the data in the file (average speed, duration, route length, ascent, descent, graphs). But also, such data were mentioned that are not present in the file at all nor they can be calculated from the available data (map, heart rate).
- Pupils also asked questions confirming that they did not realize the fact, the route saved in their GPX file had been traveled and recorded in the past (“Where am I? Where to go? When will the route take place? How long will my route take? How fast will I move?”).
- Pupils gave vague or ambiguous wording of their questions (“How high are we? What are the coordinates?”)

Next, pupils were processing the GPX file using a map software to answer questions formulated before:

*Task 3 (Explaining): View the route saved in your GPX file in Google Maps. Find out where the route is situated and name it appropriately. Study the route’s*

statistics in its description. Complete the description with appropriate text and images.

Some solutions contained a transcript of the route data as calculated by the map software not corresponding to questions formulated by pupils in previous task. The rest of pupils tried to formulate answers to their own questions. In case of ambiguous questions, the answers were either missing or clarifying the question (“Altitude? - at the beginning 138 m, at the end 134 m”).

Approximately half of the pupils did not name their route, or they gave it a neutral title, the one of their work files (e. g. “file1”). This task was focused on the ability to capture the essence of the file’s contents and verbalize it concisely. For pupils, it was either difficult or they did not consider it important. Even teachers did not pay attention to this in their comments.

In the phase of extending/elaborating, pupils recorded routes using mobile devices and after returning indoors, they visualized it in a map software. The results varied as for their complexity – from simple random doodles a few meters long to routes having several kilometres representing meaningful pictures.

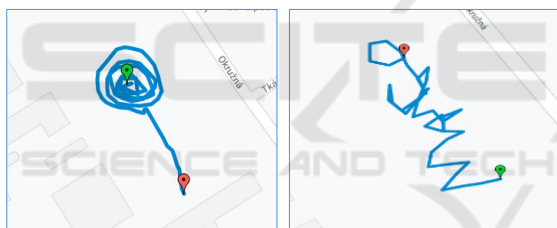


Figure 3: Drawings on free space (Rose, MANGO).

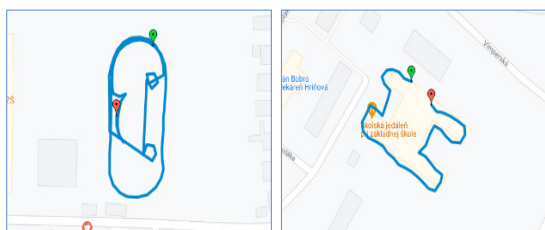


Figure 4: Drawings aligned to objects (Athletic smiley, Letter H).

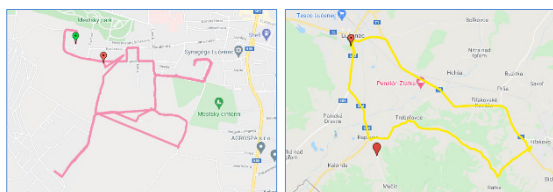


Figure 5: Drawing along the roads (Figure, Seal).

Most of the drawings were recorded on larger open areas around the school (Figure 3) or were copying the outlines of objects situated around the school, e. g. buildings, fences, playgrounds (Figure 4). Longer routes were made along the roads and pupils recorded them while cycling (Figure 5).

Teachers reported problems with procedural knowledge in relation with this part of the teaching: “Pupils did not know how to use the mobile application well, they also had difficulty transferring files.” “Surprisingly, many pupils have encountered the need for downloading data from mobile phones to computers for the first time.” “The map creation (routes in Google Maps) has not yet been automated enough.” There were also problems with bad weather and bad GPS signals.

Teachers assessed the involvement of pupils mostly positively: “Pupils were so focused on work and started enjoying it, so it was a problem to get them off the field.” “Pupils expected creating nicer pictures, but the topic was appealing to them, and some of them even tried the application later – outside of class.” “Students like to work with mobile devices and applications.”

In the final evaluating phase, pupils were asked to fill in a self-assessment section in their worksheets. They were indicating the achievement of objectives by approving provided statements:

- I can name at least 3 types of files and applications for their processing.
- I can name at least 3 types of data that a GPX file contains.
- I can view the contents of a GPX file in Google Maps.
- I can find out the length of the route, duration, average speed, ascent, descent from the data in the GPX file.
- I can record a route using tablet or smartphone with GPS and the My Tracks or Locus Map Free app.
- I can transfer a GPX file from a mobile device to a computer.

Most pupils indicated that all goals had been met. However, there were also answers in which the pupils admitted that they had not acquired some knowledge or skills. Most often, they could not name the file types and applications to process them. They also stated problems with recognizing the meaning of data in GPX files. In the second part of the activity, some pupils admitted that they had not learned to use a mobile device to record a route and transfer a file from the mobile device to a computer.

The pupils' problems they indicated in the self-assessment rubric matched the problems reported by teachers. From their point of view, the least problematic was the using of digital map (pupils could view the routes and reading the statistics). Teachers mentioned only some technical issues related to signing into the Google accounts.

### 3.3 Discussion

*RQ1: What is the knowledge level of lower secondary pupils as for the field of data representation and tools for their processing?*

The results of the analysis of pupils' products (completed worksheets, recorded routes) give us a picture of their knowledge level. Numbers of responses in individual categories depicted in Figure 2 correspond to the experience of pupils in the 7th or 8th grade – they have the most experience with text documents, followed by pictures, computer presentations, multimedia, and tables. In these categories, pupils usually did formulate the correct answers using the appropriate terminology, which indicates knowledge at high levels of BT – they know the specific data files, understand that a file is a set of data of some kind, know data files of different types as well as the applications suitable for their processing. Their knowledge is not formal, it is based on experience from lessons.

We expected a larger share of answers in the category of program code files, given that the topic of programming makes up about a fifth of the computer science curriculum in Slovakia. We explain this by saying that if pupils use an online environment for programming (e. g. Scratch), projects are automatically saved in the cloud, so pupils have no explicit experience of saving them to files.

Responses in other categories mostly represented knowledge gained through informal learning. In these responses, we noted more frequent cases of misconceptions and uncertainty in terminology. We rate these answers as naive without deeper understanding. The only exceptions were HTML files, which pupils usually named correctly (age-appropriate), even though this is not the content of the formal lower secondary computer science education.

In classes with problems reported, the teachers pointed out, that “pupils know how to work with files (delete, move from folder to folder), but to define what a file is, they have a problem with that”. Thus, they have procedural knowledge of working with files, but lack a deeper conceptual knowledge of files and data types.

The proposed methodology gave us a good opportunity to explore pupils' higher levels of knowledge and cognitive skills (file data analysis, abstraction of essential data from the file, data structure recognition) as well as the generic skills (critical thinking, question and answer formulation, technical skills, and creativity).

From the analysis of pupils' responses and feedback from teachers, we conclude that the task was appropriate to the age and abilities of the targeted group. In other words, the pupils can achieve a level of knowledge about data representations and tools for their processing at higher levels of abstraction.

For example, some teachers reported that pupils “were able to analyse the contents of GPX files with ease and used suitable application to obtain information from data in the GPX file”, “managed to work with files, found an application that opens a GPX file and independently evaluated provided data”. As part of this activity, pupils gained their own experience in interpreting structured data expressed in a markup language that is readable by both the computer and the human being.

According to the results of the data analysis, the most challenging task for pupils was to formulate questions (“It was problematic to formulate questions that can be answered using data from the GPX file.”). One teacher explained his evaluation like this: “Finding the answers, which we can find out from the available files, was initially embarrassing – pupils expected “ready-made” information.” The teacher's comment is rather optimistic as the attitude of pupils had been changed and was caused by the lack of experience with the IBL method.

Mistakes in the wording of questions revealed misunderstandings of the concept of one's motion path recording, but also a lack of generic skill to clearly formulate the problem.

When working with mobile devices, we found that although pupils use tablets and smartphones in their personal lives, their technical skills are limited to working with selected applications. Capturing and recording data to a file and transferring them from a mobile device to a computer for further processing was a new experience, which contributed to the development of their technical skills in working with mobile devices. Some pupils discovered new features of the mobile route recording application independently (“They changed color and thickness of the route being drawn.”), installed the application into their own mobile phones and recorded other routes in their free time. Drawing with GPS develops pupils' creativity.



*RQ2: How is the proposed methodology beneficial for developing the conceptual knowledge at higher levels of BT?*

The effectiveness of the proposed IB methodology depends to a large extent on its correct implementation. In the first year of verification, we received feedback from teachers, in which teachers confirmed the achievement of goals, but also those that described problems and failures.

We will describe one case of an unsuccessful implementation of the methodology in practice. In the first phase of engaging, the teacher was to involve pupils in researching what data GPX files contains and what software is applicable for displaying and processing it. Pupils were to consider different types of files and applications. The pupils' involvement was aimed at systematizing their knowledge of computer science, recalling types of files with which they have age-appropriate experience (they have worked with them in class) and preparing a suitable context for discovering a new type of data in a GPX file. In his report, the teacher stated that he considered this learning activity unnecessary because "it did not pursue the main goal, which was geolocation data." The teacher's failure to identify with IB method had been reflected in pupils' work: "Not only were the pupils demotivated at first because they could not move on their own (I had to intervene), but some also eventually skipped the task to complete it at the end of the lesson."

By omitting the engaging phase, conditions were not created for pupils to examine the contents of the GPX file independently, and the problems continued. According to the teacher, "the inquiry method is not very effective in this case, because it is a relatively difficult task, which is also problem for older pupils." Instead, the teacher suggested a traditional explanation of "how to open a GPX file than just asking pupils what software we can display it with" that would be more effective. However, in terms of developing conceptual knowledge, pupils would gain additional isolated, specific knowledge without being placed in a more general context.

In the exploring phase, after viewing the contents of the file in Notepad, based on the teacher's instructions, "pupils identified different information in a tangle of different tags and actually guessed it", so they managed to discover what data is recorded in the file. However, the teacher added a note to his report that formulating the questions we can answer based on the data in the file is a very similar task to finding out what data is in the file, and "pupils could have legitimate objections as to why they should write questions, when they already know what the file

contains." The teacher does not realize that by processing the data, additional data may be obtained that is not in the source file. This task has been included in the methodology to stimulate analytical and synthetic thinking about how much information is contained in the data. Instead, the teacher suggests formulating ready-made assignments for pupils – what pieces of information they should look for in the data.

Since pupils did not formulate the questions that would require processing of the file by a map software, the teacher no longer continued in this part of the activity. He went with pupils outdoors to record routes. Data on whether his pupils know how to process a GPX file with a map software and whether they know how to record a route using a mobile device was not provided.

After analysing this case of unsuccessful implementation of the methodology in practice, we implemented an intervention in the research – we updated the methodological guidelines for teachers to better clarify the objectives of individual activities, we supplemented the recommendations for solving documented problems.

The other teachers applied the IB methodology according to our instructions and described only partial problems. As the benefits of the IB methodology and outdoor teaching, they stated:

Content innovation:

- a new type of data – geolocation data: "Despite the fact that pupils now have a lot of information, the topic of the lesson was new to them and obviously interesting to them.",
- new applications – digital map, route recording application,
- working with mobile devices: "Pupils had the opportunity to work with a device other than a computer within a computer science lesson, they used a different operating system."

Innovation of the work form:

- outdoor learning: "creating a space for learning outside the classroom using one's own mobile devices", "reviving stereotypical lessons",
- homework: "voluntary and leisure activities",
- learning in groups: "the team's work in the exterior was very popular with pupils as well as with me (the teacher)".

Innovative methods:

- discovery: “Structured inquiry research designed in the methodology appropriately guided students to solve tasks and meet goals.”, “IBL method motivates students and leads them to creativity and thinking.”.

## 4 CONCLUSIONS

Pupils have knowledge of different types of data from formal education at school as well as from informal learning outside the school. Their knowledge and skills in using mobile devices are mostly acquired through informal learning in everyday personal life. The results of our study suggest that the knowledge gained in an informal way is not systematic and is mostly limited to practical procedural knowledge of working with specific applications and data types. In formal school teaching, the conceptual knowledge is cultivated. Pupils gain new experiences from a wider area than in everyday life as they are being involved in situations purposely designed for achieving better understanding and systematization. Pupils' thinking and their ability to express themselves using proper terminology is cultivated as well.

The lesson scenario from our study is based on IBL principles and was designed to develop pupils' analytical and synthetic thinking, the ability to formulate problems, to suggest solutions by promoting an active constructive way of learning. The data collected during the scenario's implementation at several schools in Slovakia show that the IB methodology was successful in achieving educational goals at higher levels of BT. Feedback from the teachers who were involved in the research implies that outdoor teaching of computer science and working with mobile devices is an interesting alternative to traditional lessons taught in a classroom.

Although teachers reported some difficulties related to preparing such a form of teaching (issues of hardware, software, weather, and lack of time), they were confirming that this change in form brings a significant benefit of stimulation of pupils' interest in the subject of teaching.

Our research was aimed at determining the success of one learning scenario. Though the findings are promising, they have limits as for the possibility of generalization. The presented study is part of a wider action research, which aims to design quality scenarios of outdoor computer science lessons with meaningful use of mobile devices.

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