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The Open Data Newsroom: A Game Approach for Developing Open Data Competencies in Elementary School

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Abstract: Open Data refers to digital data that is made available to anyone with the legal and technical conditions to be freely used, reused, and redistributed. Although it has emerged as a new common with the potential to increase citizen participation and transparency, current literature suggests the lack of skills for managing data and participating in Open Data processes, as one of the main barriers to achieve these benefits. Integrating Open Data in school education has been recognized as key to fostering a larger community able to participate in Open Data ecosystems. This study showcases the design of a role-playing game grounded in authentic learning principles for the development of Open Data competencies in elementary school. The Open Data Newsroom is a game approach that immerses students in solving a mystery with data. In the game, students play Open Data Journalists engaging in a three-phase authentic process to get, understand and deliver data. The learning goal in the game is that students build open data competencies: data literacy and real-world problem solving. A design-based research methodological approach is applied to develop theory based and practically grounded educational designs. Two interventions in Danish schools have been conducted, each one with the participation of seventeen students in 7th to 9th grade and three teachers. Interventions are aimed at iteratively designing and testing the game. The discussion section elaborates on opportunities for redesigning and systematically developing the game as a learning design for Open Data competencies.

Keywords: Open Data Competencies, Open Data Literacy, Authentic Learning, Elementary School Students, Game Design, Open Data Journalism

1. Introduction

Open Data (OD), which is data made freely available to anyone, has been stated as a new common available for all members of society (Morelli et al., 2017; Mulder et al., 2019). Although OD is leveraged to increase citizen participation and social value (Kassen, 2013), few citizens have the competencies for actually achieving these benefits (Janssen et al., 2012). Within the OD field the lack of skills of citizens for managing data and integrating in OD processes is a major concern (Van Loenen et al., 2021). This represents a challenge for achieving OD ecosystems (Van Loenen et al., 2021) where people engage and benefit from available OD to participate as active citizens, critically think about governmental performance and create novel products and services. OD is then an available resource but lowly exploited since the majority of people struggle to engage with it. Although integration of OD in schools has been established as one of the strategies for promoting inclusive and fair OD ecosystems (International Open Data charter, 2015), educational designs, tools and methods are still scarce.

Current OD initiatives in education mainly seek to equip students with essential skills needed for the current fast changing and data-driven society (Cook et al., 2018). Potentials of using OD mainly have been related to the connection of classroom activities to real facts, and secondly, to increasing teacher's and student's motivation (Coughlan, 2020). OD learning activities have ranged from using OD in regular school subjects such as chemistry and geography (Pence et al., 2015), engaging with local problems and data in undergraduate courses about OD (Palova & Vejicka, 2022), and extracurricular activities such as public hackathons (Davis & Shneyer, 2020). Previous research has shown that the learning goals of current initiatives in elementary school are often related to increasing awareness about OD and developing criticality (Celis Vargas et al., 2023). For example, Badioze Zaman et al. (2021) focus on preparing young students to use OD by using in the classroom pet robots and IoT, and Saddiqa et al. (2019) have related data literacy in schools with the ability to identify which types of data are needed for solving a problem, and the abilities to use visualisation technologies for exploring and presenting the data in greater detail and understandable way. Furthermore, research of Pellegrino & Antelmi (2023) has shown that OD initiatives in school level primarily are focused on the use of open datasets or data exploitation rather

than on their production. The development of OD competencies based on data literacy and real-world problem solving in elementary school students has been the focus of the development of learning designs that allow future engagement and current participation of elementary school students in OD ecosystems (Celis Vargas et al., 2024).

The current paper investigates how it is possible to develop a game-based learning design for students to develop OD competencies in elementary school. We present the design of a game approach and preliminary test results. Some of the main design considerations include making OD less abstract for non-technical users, and getting students engaged in the process of learning data literacy competencies for solving real-world problems.

2. Background

With the aim of developing tools and methods for building OD competencies in elementary school, a game approach was designed based on authentic learning principles and with the goal of building competencies for Data Literacy and Real-World problem solving. The goal was to enhance the authentic aspects, and theoretical and experimental practices by assigning students the role of Data Journalists in the game. According to Gray & Bounegru (2024) data journalism is a critical data practice including a reflexive work and considering not just the ways in which data is analysed, created, and used, but also the social, cultural, political and economic circumstances in which such practices are embedded. This perspective provides an authentic frame for learning OD competencies which are grounded in data literacy and real-world problem solving.

A game-based approach helps to make the knowledge that is abstract and common for experts more concrete and embedded in a situation (Greeno & Gresalfi, 2008) by acquiring new words and new forms of language for using OD for real-world problem-solving. Games are a form of active learning that enable the learner to have some control of the game activity and engage in interaction (Gee, 2004). Game-based learning (GBL) is grounded in active learning methodologies and encourages learning activities by building on engagement and challenges to achieve the intended learning objectives (Romero et al., 2015).

Essential elements of game design have been described by Costikyan (2002) as five: goal, struggle, interaction, structure, and endogenous meaning. In brief these can be described as defining clear goals for players to strive towards, creating a sense of purpose and direction within the game. Struggle and challenge in fostering players' engagement and satisfaction. The internal rules and systems, known as endogenous mechanisms, that govern players' interactions and outcomes. The importance of structure in organising gameplay elements and guiding player progression. Finally, the interaction refers to both within the game environment and between players.

2.1 Data Journalism

From Journalism's foundation, journalists have used a plethora of approaches to explore, detect, and uncover newsworthy stories. In our contemporary society, the plethora of data that is available to journalists led to the establishment of the term 'Data Journalism.' According to Veglis & Bratsas (2017), it involves the use of data at all stages of the journalistic process including the extraction of information, compilation, and visualisation in a comprehensive way. Furthermore, with the adoption of the OD movement by governments all over the world, new data sources have been made available to journalists. According to Papageorgiou et al. (2023), OD provides them a better insight into important social problems and government activities to create 'evidence-based' journalistic articles.

According to the Data Journalism handbook 1 (Bounegru et al., 2012), the data journalism process consists of three major moments: Getting data, Understanding data and Delivering data. Initially, the data collection step or *Getting Data* can incorporate gathering data from a variety of sources. This can include scraped data, data acquired from freedom of information requests, publicly available data, and OD provided by governmental or other institutions. After the data collection, the data that is of interest to the journalist have to be analysed. The *Understanding data* step requires the discovery of trends, patterns, and the extraction of insights. The next moment, *Delivering Data* requires thinking of different audiences and may include serving data with stories, data driven applications and data visualisations. The perspective of data journalism as a critical data practice emphasises on the process of inquiry with data (Gray & Bounegru, 2024).

3. The Open Data Newsroom

The Open Data Newsroom is a role-playing game for elementary school students to solve a fictional mystery with OD through engaging in authentic activities as real data journalists would do. The game is a simulation grounded in two authentic elements. On one hand, the game develops around a mystery which is relevant for students and close to a real-world complex challenge. On the other hand, in the game students act as data journalists engaging in a simulation of an authentic OD process.

The game builds a narrative where professional data journalists in a local newspaper receive a call from the *Global Investigative Open Data Network* to unravel mysterious events that they believe are connected. The *data journalists* (students) in the newsroom work on getting, understanding, and delivering data to explain the mysterious events to the community in a press conference. The *chief editor* (teacher or external facilitator) facilitates the game flow and challenges the data that the students' outcome is based on. Data journalists are divided in teams of 4 to 5 people trying to have a variety of interests and abilities. The game dynamic guides the players into a data journalistic process where activities relate to OD abilities such as finding and analysing data, assessing if some data is real or fake, creating visualisation and presenting a data-based story explaining a problem. Table 1 presents the game flow that consists of several phases guiding the players into the game narrative and data journalistic process to achieve the outcomes. Game phases are mainly five: (1) introducing the mystery and goal, (2) getting data and understanding data, (3) preparing a data story, (4) editorial meeting and (5) delivering data. First the mystery, game goal and dynamic are introduced to the players. Following this step, a phase of getting and understanding data immerses the journalists' teams in two activities supported by physical and digital elements. On the one hand, the players start defining storylines based on further information about the mysterious events. On the other hand, the players navigate open datasets presented through interactive visualisations to analyse the facts behind the mysterious events and identify data insights to unravel the mystery. In the third phase, the journalists receive instructions to prepare for the press conference where they will deliver a realistic and convincing story based on data to the local citizens. At the same time, each team works on building their final data story and presentation. An editorial meeting helps them to strengthen their outcome. During the editorial meeting, the chief editor meets each group to hear their hypothesis and challenge the storylines and the data behind. Finally, the phase for delivering data has arrived. Each team presents their story receiving questions from the critical audience. An official solution is presented by the chief editor. The game is finalised with comments from the chief editor to each team and an introduction to work on a future press release and to leverage the data generated during the investigation. Figure 1 shows the interaction and engagement of players during the different phases.

Table 1: Game flow

Game Phase		Description
Introducing the mystery and goal		The chief editor presents the mystery, game goal and dynamic
Getting and understanding data	Defining storylines	Players receive physical envelopes with news and social media posts about the mysterious events to build their own case
	Finding data insights	Player analyse OD through visualisations in the platform
Preparing the data story		Players prepare for communicating their solutions to local citizens in the press conference
Editorial meeting		Each team meets the chief editor for max. 5mins
Delivering data: Press conference		Each team presents in max. 5 mins. The chief editor presents the case solution



Figure 1: Players engaged in different game phases (anonymised). From left to right: 1. Players creating a case board while defining storylines (Getting data). 2. Players interacting with the online tool during analysis of data and finding data insights phase (Understanding data). 3. Players presenting their data story in the final Press conference (Delivering data).

Considering that the expected learning outcome is the critical analysis of data for solving problems, OD activities in the game focus on the analysing of data visualisations rather than on the management of raw data. Players navigate different interactive visualisations in a digital and online platform. In the game, we have used two datasets in connection to the game mystery, one related to water quality and one related to teenagers' health issues. Firstly, the *Bathing Water Directive - Status of bathing water*, Denmark dataset (European Environment Agency, 2023) is used. Associated metadata is briefly presented in the game platform. This repository presents data from 2009 to 2022 and we created data for two more years 2023 and 2024 since the mysterious incidents are occurring in the current year. Secondly, we created a second dataset about skin disease cases in Denmark following the same structure of the previous dataset presenting data from 2009 - 2022.

4. Methodology and Test Design

The Open Data Newsroom has been tested in two Danish schools with students aged 14 - 16. The focus of these tests has been to investigate the following research perspectives: firstly, the study aims to understand how OD competencies for Data Literacy and Real-world problem solving can be developed in elementary school. Here we were particularly focused on understanding how the game strengthens students' skills for critically analysing data, distinguishing between real and fake data, solving problems with data, and building a story. Secondly, we aim to understand students' interests and motivations for engaging in solving a problem. These research perspectives have been tested in two cycles of research and development which will be described below.

4.1 Design Based Research and Interventions

A design-based research (DBR) methodological approach is applied to develop theory-based and practically grounded educational designs (Bakker, 2018). In DBR, design experiments aim to produce actionable knowledge that can be used to achieve some educational goal through design (Cobb et al., 2003). DBR develops in iterative cycles of problem definition, design, intervention, and redesign (Brown, 1992). Two cycles are aimed at iteratively developing and testing the game design with students and teachers. The first intervention was developed in January 2024 in a Danish school with 17 students in 7th grade. The second intervention was developed in March 2024 in a different Danish school with 17 students in 8th and 9th grade.

Figure 2 visualises the two cycles and iterative process.

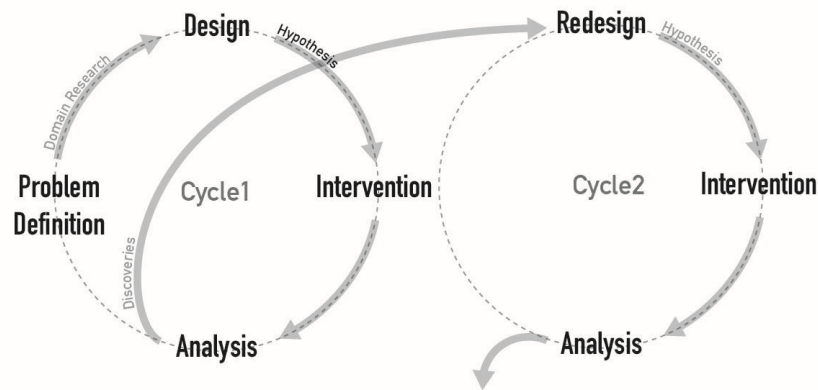


Figure 2: Design Based Research DBR cycles and iterative process.

In the first cycle of design and intervention with the game, the focus was on testing if the game created an authentic experience as data journalists for the development of OD competencies and the general engagement of the students with the mystery and the narrative. In the second cycle, the focus was on strengthening the experience of the students for using OD to solve an authentic challenge. Based on the results from the first intervention, the game was further developed to address areas of improvement such as the mystery being too simple (thus not sufficiently challenging and satisfying for students), the role of data journalist being loose (hence not contributing much to solving the mystery), and the data being highly abstract and in a rigid format (not facilitating deeper analysis).

Interventions were conducted in Danish schools during regular school time and with the presence of the teacher who occasionally engaged in asking critical questions to the students. Each intervention lasted 3 hours. During the intervention the researchers introduced the research aim, the game, and the role of data journalists to the class. Following the introduction, the test of The Open Data Newsroom was conducted during approximately 2 and a half hours. One member from the research team adopted the role of *Chief editor* to facilitate the game flow. Meanwhile a second member of the research team focused on making observations during the whole session. During the first intervention students were asked to create physical visualisation and several materials such as colour papers, markers and paper sheets were given, however two out of four teams opted for creating slides presentations for the final press conference. During the second intervention, students used their own laptops for the data analysis using the platform and preparing slides presentations for the final press conference. In both cases, students discussed storylines and hypotheses to solve the mystery. Table 2 summarises the main characteristics of each intervention.

Table 2: Description of interventions

Intervention	School 1	School 2
Participants	17 students in 7th grade aged 14 to 15 1 teacher	17 students in 8th and 9th grade aged 15 to 16 2 teachers
Game teams	4 teams (3 teams of 4 students and 1 group of 5 students)	4 teams (3 teams of 4 students and 1 group of 5 students)
Duration	3-hour session	3-hour session
Design tested	Physical game elements	Physical and digital game elements

Students' participation was documented using audio and video recording as well as photography. The class was asked to complete a written questionnaire with two qualitative questions "What did you like about the activity? Why?" and "What was the most challenging? Why?". In addition, semi-structured qualitative interviews (Kvale & Brinkmann, 2005) were conducted with the entire class for around 30 minutes, and with the teacher for 45 minutes after the test. During the interview, students answered qualitative open questions related to their game experience, the learning experience, and the game development, such as "How did you feel as Data Journalists solving the mystery? Was it interesting? Was it fun?" "What was different from everyday teaching?" and "How could the game be more interesting or fun for you?"

4.2 The Iterative Development of The Open Data Newsroom in School Interventions

The Open Data Newsroom was developed and iteratively modified with the specific focus of serving as a learning design for developing OD competencies in elementary school. The learning outcomes refer to competencies for the critical analysis of data for solving authentic problems. Examples of the iterative design are making the mystery more complex in relation to the data analysis and integrating a digital tool for the analysis of data. During the first intervention the students received two envelopes, one with printed news and social media posts about the mystery, and a second envelope with printed data in different formats such as visualisations and statistical reports about the mystery. During the game-playing session the students struggle to analyse the data in these formats, losing interest and motivation to dive deeper in the game. Later, during the second intervention we added a digital platform for analysing data through data visualisations. Figure 3 shows two groups of students during the interventions, firstly analysing the case physically and secondly, engaging with the digital tool included for the data analysis.



Figure 3: Students during the game-playing session (anonymised). On the left, the first intervention with a physical game. On the right, the second intervention included physical and digital game elements.

During the first interventions students concluded the solution without the help of the data, it was too obvious for them. Therefore, during the second intervention we increased the complexity of the mystery in relation to the data analysis. Students needed to discover hidden clues in the printed material about the mystery, and during the data analysis they had to consider several variables such as the time frame, the number of cases over time, and the age of the sick teenagers.

The digital platform was hired as a service (Juice Analytics, 2024). This solution was the only platform that we identified allowing users to immerse in interaction with visualisations for data analysis and data storytelling. The intended audience for the platform is a commercial audience, however, we found it highly useful and relevant also for educational purposes. This platform allowed us to create an online report as a landing page with our own images, narrative, and datasets. This online tool allowed the students to interact with several data visualisations by filtering, correlating variables, and capturing their insights. Figure 4 shows the final interface and the type of data visualisations presented to the students.

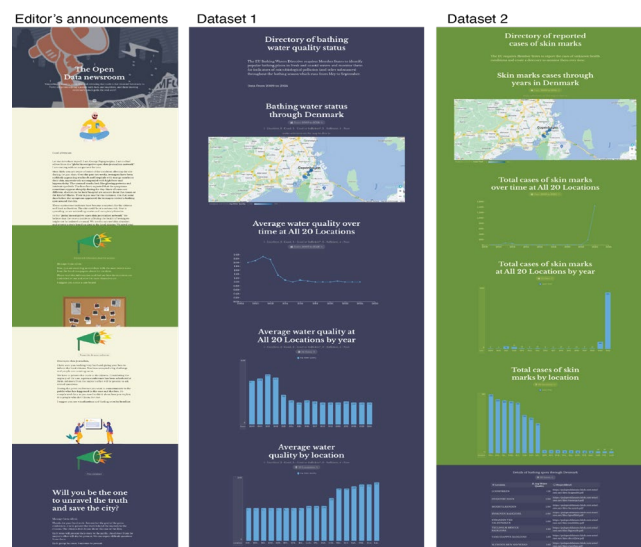


Figure 4: Final game interface in the platform

5. Results

5.1 Test in School 1

Students could solve the mystery in the game, however they did it very easily without the use of data. Their solutions and analysis lacked depth and were overly simplistic. These results show a lack of engagement with the game and a faulty demonstration of OD competencies. For example, one student commented that "The final product was hard to make, as only one other person did any work". We could observe that the mystery was overly simple and did not need data to be solved. For example, students commented in the qualitative interviews and the written questionnaire after the test that "the subject was kind of boring", "There wasn't anything difficult about the subject". During the final presentation, some of the teams created fictional narratives such as a team that elaborated on a lethal virus that was the cause behind the mystery. Even though this narrative helped them to personalise and differentiate their story from the other teams, it was not originated or supported by the data provided. During the press conference, all teams had the same conclusion, and the argumentation was insufficient. Furthermore, we observed that students were initially interested and motivated, but especially during the data analysis moment, some students began to lose interest. Results from the qualitative interviews after the test and written questionnaire indicate that the data was highly abstract and difficult to process. These results were discouraging, but it was a clear indicator of the need of a digital tool for the interaction with data, and for designing a more complex and engaging mystery.

Regarding the authentic experience as data journalists, students did not fully immerse themselves in the narrative. In the qualitative interview they expressed that they did not feel like data journalists. However, in the written questionnaire, students commented positively about the activity regarding the role and the goal. For example, "It was cool that we got to create a solution" "I liked figuring out by ourselves why people got sick" "It was cool doing role play".

5.2 Test in School 2

In summary, the results showed that the students displayed a high level of analytical depth and comprehension in unravelling the mystery. Their solutions and final presentations were characterised by thorough exploration and nuanced understanding. We could observe that students exercised OD competencies in the game such as the identification of a problem, critical analysis of data to solve a problem, assessment of real and fake data, creation of a data story to communicate their outcomes, identification of needed data to be collected, among others. A very interesting observation is that several teams of students questioned the veracity of the datasets in the game. For example, some teams discovered that the bathing water status open dataset was presenting data from 2024, however the bathing season has not yet started. This insight showed us that the students engaged deeply with the data and metadata. Students also identified that the social media posts given in the first envelope to contextualise the mystery were not providing relevant or useful information. One of the students mentioned "the social media posts are misleading and have no data". These reflections led discussions in the different teams about the veracity of the sources. Furthermore, during the final press conference, students were able to present their final data story using data for argumentation by referring to time frames, quality of the water, locations, and number of cases. The students used data visualisations to present their hypothesis. Two teams found additional relevant geographical open data on their own initiative to create hypotheses about other phenomena possibly related to the mysterious events such as rain levels or high temperatures. Figure 5 shows an example of an insight captured by one team during the data analysis and used as visual support for the final presentation.



Figure 5: Data insight from the visualisation captured by a team of students during the game test in school 2. Student (anonymised) using the data insight during the editorial meeting.

The game and set up in the class provided a strong experience of engaging in an authentic OD professional use. For example, students commented in the written questionnaire that "It was an engaging story which actually made me want to find the answer. The website was well designed and helped with our research ", "It was fun because we got to be like journalists", "It was interesting to investigate and find reasons why our theory was or wasn't right", "I liked the topic about the disease, it was interesting". The authentic narrative helped the students to make decisions and focus on a storyline to build their narrative. For example, one student during the qualitative interview said, "The narrative helped me to think in my audience and decide what to say and how to present the story during the press conference". Regarding the engagement with the mystery, the teams deepened in their understanding. Two out of four teams explored different hypotheses beyond the one thought by the researchers' team. In addition, students identified the need for more data which could lead to a further development including data collection. Furthermore, results from the qualitative interviews and written questionnaire show that the challenge in the game or struggle was adequate and engaging for the students. Referring to what they liked about the game, students commented on "How interactive it is and how it easy to follow - but not easy to solve", "it got us to think, and analyse our information", "I liked the challenge that we got and the perfect amount of data for us to find out the problem". Finally, physical, and digital elements contribute to each other and enhance the experience, as a student commented "I liked that it was very interactive. It was both on the computer, but you also wrote stuff down. The website was very easy to use".

6. Discussion and Conclusion

The results presented in this paper show that a game approach increases students' understanding of OD, their awareness of what it is, how it is created and how it can be critically used, but also allows them to exercise OD competencies associated with Data Literacy and Real-world Problem Solving. Furthermore, the game approach contributes to understanding learning designs for the use of OD in elementary school. The results described in this paper indicate that a game approach integrating authentic knowledge close to students' interests offers new approaches to develop learning designs for OD competencies in elementary school. This approach might also be applied for understanding social issues in elementary school and create a reflection on the students about the need and assessment of data.

Results of the second iteration show that various design challenges remain to be addressed even further. This presents an opportunity for further systematic development of the game with students and teachers. Challenges to be addressed are related to several aspects of the game, for example the team formation was done by the teacher, however groups could be created according to the interests of the students in order to make the game experience more relevant to them. During qualitative interviews, students and teachers elaborated on the slightly unpleasant experience of presenting the same solution but from different teams during the press conference. In the future, teams could collaborate on different aspects, working together as a big newsroom. Students were constantly in need of feedback during the game which was addressed by the editor and during the editorial meeting, however feedback mechanisms on OD skills development could be explored in upcoming iterations. For the final press conference that at the same time is the end of the game, for some students it was not rewarding enough, perhaps including an authentic critical audience could enhance the authenticity of this final moment. Finally, regarding the OD competencies, an extension of the game could address more competencies such as the integration of data collection activities and simulation of the interaction between stakeholders, as it occurs in real OD ecosystems.

Further research could drive frameworks for the integration of this game approach in school curriculums and for the assessment of the learning outcomes.

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