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Learning Designs for Developing Open Data Competencies in Elementary School

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Abstract. Current literature argues that the lack of skills for users to engage in Open Data ecosystems is a primary barrier to expanding the benefits of Open Data in society. Although schools have been identified as potential actors in promoting Open Data literacy goals, educational approaches to support this aim have not been clearly defined. Our previous research on Open Data skills definition indicates that focusing on data literacy and real-world problem-solving is crucial in Open Data Education. In the current study, we apply a design-based research methodological framework to investigate how learning designs for building Open Data competencies in elementary school can be developed and what educational design elements are relevant. Design-based research proposes iterative cycles including problem definition, design, intervention, analysis and redesign. An exploratory cycle from problem definition to the first intervention with an educational open data design has been conducted. Central design elements, including elements of game-based learning, are identified by reviewing the domains of data literacy and real-world problem-solving. An educational design was tested in a Danish school with 39 pupils aged 15 to 16 in 9th-grade and five teachers. Following a thematic network analysis methodology, the results provide a contextual understanding of the competencies and skills for using Open Data in elementary school, how to keep students interested and engaged, and the importance of authenticity for Open Data learning designs. We propose a game design, making a parallel between learning and game design elements. The game design uses Open Government Data, and authentic Open Data practices for engaging elementary school students in developing Open Data competencies. Our study contributes to the understanding of social contexts and new technologies in the Open Data field showing the value of real-world applications and public value generation using Open Government Data.

Keywords: Open Data learning design · Open Data education · Open Government Data

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1 Introduction

Increasing citizen participation and the creation of social value have been defined as benefits of Open Data (OD) in society [1–3]. Although OD has been stated as a new resource available for all members of society, a large part of citizens face barriers associated with the complexity of technically managing data, and the participation in OD processes such as exploitation and provision of open datasets [1, 4]. Often, using OD requires specialised data abilities for accessing, curating, interpreting data and creating data-based products or solutions [1]. In OD ecosystems, actors can adopt different roles as users, data providers or intermediaries in interdependent and dynamic ways [5]. The expanding role of data in society highlights a need for educating citizens who are not meant to become specialists, but who are able to integrate methods, tools and resources based on data, and connect to data-based systems [6]. The role of OD education is therefore gaining relevance to foster what could be seen as an open data-literate community that can benefit from OD and participate in OD ecosystems rather than only the smaller part of citizens with technical backgrounds [7]. Specifically, the integration of OD in school education has been proposed as a way to ensure inclusiveness and fairness in OD ecosystems [8]. Schools serve as fundamental institutions where children and teenagers learn essential knowledge to actively participate in society and future labour markets [9].

Despite the stated importance of integrating OD in schools, in a previous review, we show that most learning experiments involving OD have been applied in higher education [10]. The fewer existing studies about OD education in elementary schools highlight its potential connecting classroom activities with real-world data [7, 11, 12]. The integration of OD in schools has been shown to increase public engagement and develop data and digital skills [13]. For example, previous studies have shown that the use of data from students' municipalities increases their interest in everyday life problems and fosters discussions in the classroom [14, 15].

Our previous studies focus on building OD literacy in schools, not just by equipping young pupils with technical skills but also by allowing them to engage in local contexts and communities [10]. However, learning designs have not been clearly defined, OD has been mainly used to teach subjects such as geography, history, or statistics [13, 16], and the exploration of OD rather than the students' creation of it has been prioritised [17]. This paper seeks to answer the following research questions: How learning designs to build OD competencies in elementary school can be developed and what educational design elements are relevant? This study contributes both to the definition and implementation of OD competencies in elementary school and to the understanding of the central elements in learning designs for educating young people to take part in OD ecosystems.

2 Background

A literature review on OD education has been previously conducted to define the OD skills needed in education including studies from primary school to graduate programmes [10]. Two central groups of skills were identified. Firstly, a group of skills related to data management or *Data Skills*. Secondly, a group linked to engaging in local contexts and communities or *Context Skills*. Table 1 summarises the mapped skills in previous studies.

Table 1. OD Skills from Celis Vargas [10]

Data Skills	Context Skills
Computational thinking	Problem analysis
Data documentation	Conceptualisation
Finding OD	Identifying problems in real-world settings
Assessing OD	Collecting data in real-world settings
Interpreting data	Engaging with a community
Statistical thinking	Local problem-solving
Data visualisation	Storytelling
Data privacy awareness	Decision Making
Analytical skills	Interdisciplinary research skills
Leveraging OD	
Prototyping	
Data Ethics	

On the one hand, Data Skills are defined as technical abilities to manage OD. Most of these abilities, such as "Computational Thinking", "Statistical thinking" and "Data visualisation" can relate to the domain of Data Literacy [18]. Data Literacy has been defined as the combination of technical and statistical skills with the ability to draw meaning by posing questions, interpreting and analysing data, and creating visualisations [13]. It is related to several other types of literacy such as information literacy, media literacy, and quantitative literacy [19]. On the other hand, Context Skills are defined as abilities to engage and solve issues within a specific environment or community. Context skills such as "Identifying problems in real-world settings", "Collecting data in real-world settings", and "Engaging with a community" stress the importance of authentic environments for contextualising the data. In addition, Context skills such as "Problem analysis", "Conceptualisation", "Local problem-solving" and "Decision Making" emphasise an inquiry process for problem-solving. Considering the authenticity of the tasks and the inquiry process, we have related this group of abilities to the domain of Real-world problem-solving [20]. Real-world problem-solving can be defined as a dynamic analytical process to solve complex or ill-defined issues common in real-world environments [20].

2.1 Data Literacy and Real-World Problem-Solving

In the current work, we consider Data Literacy (DL) and Real-world Problem-Solving (RWPS) as key concepts for the definition of OD competencies and the development of learning design for building them in elementary school. Rather than suggesting that OD offers an entirely new pedagogy, it is important to identify links with existing teaching and learning concepts [13]. We have explored the two domains to map the associated skills or abilities, and the current educational approaches.

Data Literacy. Data Literacy (DL) has gained relevance in preparing citizens for engaging in an information and data-driven society [6, 12, 19]. It has been suggested as a central element in basic school education [6]. In the school context, DL has been defined as the ability to understand, find, collect, interpret, visualise, and support arguments using quantitative and qualitative data to answer real problems [19, 21]. Furthermore, it has been defined as the ability to ask and answer real-world questions from large and small datasets to communicate stories from data [12]. These definitions of DL in school education, emphasise creating arguments and stories that connect data to real problems.

Educational interventions for DL have ranged from focusing on skills in statistics and data visualisation to more general dispositions and competencies in analysing and solving problems with data [6]. Data Literacy has different levels of complexity, thus programs supporting a basic level of data literacy have skipped lessons in manipulating raw data, focusing instead on analysing pre-existing data visualisations [21]. Integrating DL into school curriculums has been addressed in two ways: integrating data explorations with learning objectives from a specific subject such as mathematics or statistics and splitting learning across multiple classes [21]. Several authors have supported the cross-curricular and interdisciplinary perspective, emphasising the importance of interdisciplinary thinking for teaching DL in schools [21, 22]. This cross-curricular approach has been highlighted to allow a better contextualization of the data [12].

Educational approaches to DL in school education emphasise the integration of authentic contexts as real problems, real-world settings or real data, active learning, and inquiry-based learning practices [12, 19, 21] to adapt pedagogical approaches to the context of learners [22]. For example, current approaches in school stress the use of real-world data either as open datasets or self-collected data [12], and the investigation of authentic problems using data as part of evidence-based thinking [21]. Finally, cognitivist or constructivist principles, project-based, and problem-driven approaches have been suggested to achieve the learning goal of understanding real-world phenomena through data helping youngsters to experience data's real-world impact [19].

Real-World Problem-Solving. Real-world Problem-Solving (RWPS) is often dynamic and discontinuous due to the nature of real-world problems [20]. Frameworks for 21st-century skills [23–25] have defined problem-solving as a central learning and innovation skill [26]. Problem-solving has been often related to critical thinking and decision-making [27]. According to the OECD's Programme for International Student Assessment (PISA), problem-solving relates to how students evaluate evidence, make connections between information and arguments and analyse alternative points of view [27]. Foremost, according to Dede [28], four essential skills are associated with problem-solving: (i) defining authentic problems and significant questions; (ii) managing activities to develop a solution; (iii) collecting and analysing data to identify solutions; and (iv) exploring alternative solutions [28].

Real-world problems are typically ill-defined and often have open-ended solutions which adds an aspect of uncertainty to the problem-solving process. An important dimension is the continuous interaction between the solver and their environment, in other words, the real world helps solve the problem [20].

Educational approaches to real-world problem-solving address notions of experiential learning [12]. Experiential learning stresses the idea that learning should be situated

within a real-world context and concerning students' experience rather than reliant on rote learning of a collection of facts [29, 30]. Further, such learning experiences should be responsive to cultural differences that might affect an individual learner's view of the world. In learning designs for RWPS, the real-world situation is usually addressed as an authentic activity [31]. An authentic activity has been defined as the ordinary activity of the practitioners in a culture, or activity which is congruent with their ordinary activity [31]. Often, in learning designs, engaging with these realistic tasks is presented to students to solve problems by thinking in the same ways as professionals working in real-world contexts would do [32, 33].

2.2 Open Data Learning Designs Based on Data Literacy, Real-World Problem-Solving

Learning designs focus on how to achieve a learning goal such as new knowledge, skills, and abilities that learners should be able to master [34, 35]. According to Beetham [34], the learning activity is central in learning designs. Figure 1 presents Beetham's learning design model which considers four interdependent elements for a learning activity to be completed: the learners, other actors in the learning process, the learning environment, and learning outcomes. Additionally, different learning theories create a framework for the design of learning activities.

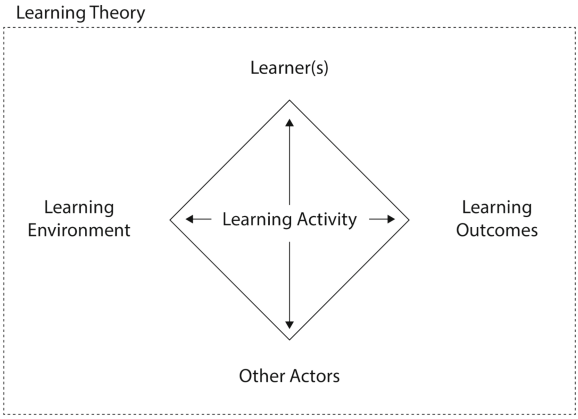

Fig. 1. Beetham's Learning Design approach. Adapted from Beetham [34].

Learning Outcomes. The expected outcome of our learning design for elementary school is the development of OD competencies for real-world problem-solving with OD. Competencies refer to the knowledge, skills and attitudes that allow individuals to act adequately in each situation [36]. Table 2 presents the summary of OD competencies and skills mapped from the domains of DL and RWPS in elementary school, and clustered as OD competencies. Five OD competencies organise a list of skills and abilities connected to DL and RWPS domains.

Table 2. OD Competencies and skills in elementary school based on DL and RWPS

Learning outcome	OD competencies	Skills/abilities from Data Literacy	Skills/abilities from Real work problem-solving
Real-world problem-solving with open data	Getting data	Access and find data. Collect own data	
	Handling data	Read, Work with, Use, Manage, Manipulate, Navigate, Clean	
	Understanding data	Analyse, Comprehend, Interpret, Critically assess, Understand underlying principles and challenges of data, Critique, Ethically use	Identifying and defining Authentic problems and significant questions Make connections between information and arguments
	Making decisions with data	Select, Observe, Evaluate, Reflect, Explore alternative solutions	
	Communicating with data	Visualise, Support Arguments, Present, Communicate stories	

Learning Theoretical Framework. According to Beetham's learning design approach, different learning theories determine different issues in activity design such as the role and significance of other people in the activity, the authenticity of the task and setting, and the structure, among others [35]. By analysing educational approaches in DL and RWPS, we identified that learning activities are usually related to authentic and experiential learning. On the one hand, students are asked to engage with authentic elements such as real problems, real-world settings, real data or real activities. On the other hand, learning activities tend to relate to the students' context and own experiences. Table 3 summarises the elements of learning designs mapped in the domain of DL and RWPS.

Table 3. Characteristics of learning designs for DL and RWPS in elementary school

Characteristic	What was considered
Authenticity	Real problems, real-world settings, real data, real activity
Situated context	Students' context, students' experience
Interdisciplinarity	Cross-curricular subject (Quantitative and Qualitative)
Tools	Technological tools for processing data

These characteristics were related to active learning experiences and experiential educational approaches such as Project-based, Problem-based (PBL), Inquiry-based,

and Game-based learning. In these educational approaches, students often work on collecting, analysing, and interpreting data to address real-world problems or questions. Furthermore, PBL approaches have been mainly applied in current OD educational initiatives [10].

The characteristics and educational approaches to DL and RWPS help to build a framework for OD learning designs, however, for applying them, it is still needed to understand how they relate to learners, environment, and other actors in OD learning activities.

3 Methodology

A design-based research (DBR) methodological approach is used to explore how learning designs for building OD competencies can be developed. DBR is defined as a theoretical and practical approach for the development of new educational approaches [37]. Iterative cycles are developed, aiming at producing actionable knowledge that can be used to achieve some educational goal through design [38]. Each DBR cycle is a design experiment that develops in four phases: problem definition, design, intervention, and analysis and redesign [38]. The first cycle presented in this study is aimed at gaining contextual understanding of current practices associated with DL and RWPS as central OD competencies, proposing an OD educational design and testing it with students.

3.1 Data Collection

An exploratory qualitative study was conducted in a Danish school with 39 9th-grade students and five teachers. The school was selected according to its cross-curricular and interdisciplinary PBL approach. Considering the interrelation between learners, learning environment, learning outcomes and other actors in Beetham's approach to learning designs [34, 35], different research methods involved the participation of students and teachers. Table 4 summarises the methods and participants involved according to the phases of a DBR cycle.

Table 4. Methods and participants

DBR phase	Method	Participants
Problem definition: domain research	Semi-structured interview	5 teachers in 9th-grade
Intervention	Test of OD educational design	39 students in 9th-grade 2 facilitators
	Qualitative survey	37 students
	Focus group interview	15 students

Domain Research. Semi-structured interviews were conducted to gain contextual knowledge on why and how teachers currently design learning activities for OD competencies. Although teachers are not experts on learning designs for OD competencies, they have experience in related elements of OD learning designs such as PBL activities, connecting real-world problems to school activities, and making school activities relevant for the students.

A Danish school that has recently implemented the PBL approach from 9th-grade onwards was chosen for the study. Individual interviews were held in the school for around 60 min with five teachers working collaboratively and interdisciplinary in PBL activities for 9th-grade. Teachers had different expertise in subjects such as mathematics, science, arts, language, and society.

The interview explored the topic in two parts. Firstly, exploring current teacher's practices on data, and secondly, exploring how to design learning activities for Data Literacy and Real-world problem-solving.

OD Educational Design. Considering Beetham's learning design approach and the background review on DL and RWPS in elementary school (Tables 2 and 3), the OD educational design for the intervention was defined to be an inquiry-based and gamified hands-on learning activity for 9th-grade students.

The ongoing school project "Utopia" served as the framework of our design. This project encourages students to critically assess current socio-political and technical systems to propose better ones by creating their own island with their own socio-political and technical systems. The OD educational design was then defined as a gamified simulation that contributed to the definition of the health system of the utopic islands. The goal of the activity was to create a data story answering the questions: How many doctors need their island per person and what kind of medical specialities (e.g., cardiology, paediatrics, dermatology)? Game elements as roles were considered. Students played in groups as decision makers or politicians and the teacher supported questions acting as the problem owner.

The dynamic consisted of three main parts: exploring data, creating the solution, and presenting it to others. Firstly, a data exploration was individually conducted. Each student found and explored data from different countries, one group member from Denmark to relate to their context and the rest group members from different islands trying to relate to the geographical conditions of their utopic island. Secondly, students discussed and made decisions about the best health system model for their island. Students created a visualisation and a data story following a template. Finally, each group presented the data story to the rest of the class.

Intervention. The OD learning design was tested in an intervention with students. The activity had a duration of two hours and was performed three times to reach the total number of 39 9th-grade participant students.

Students worked in groups of 4 people. Each student had a laptop to conduct the research and data exploration. Although the Danish Open Data portal [39] was suggested as the main source, students were free to find other sources. Most of the students opted for using Google. We provided the students with a data story template, where they registered their main findings, decisions and arguments with data. Students were also free to make

their physical visualisations to communicate their stories. Figure 2 shows the students during the intervention.

Fig. 2. Students during the intervention. From left to right: students engaged in data finding and exploration, students creating physical visualisations, and students filling the data story template.

After the test, a qualitative survey was developed to gain knowledge of the students' perception of the activity and engagement. A brief online form with two open questions was provided to the students. 37 students anonymously participated. Afterwards, a focus group interview was held with a total of 15 students. The purpose was to gain further insights into the most relevant elements for their engagement and learning of OD competencies. The focus group developed as an organic conversation for 20 min following two suggested topics: their experience during the activity and ideas for development.

3.2 Data Analysis

Considering Beetham's learning design framework, a qualitative research study was conducted to explore and gain contextual understanding of the different elements of learning designs such as learners, learning outcomes, learning environment and other participants for defining OD learning designs.

According to data processing regulations, sessions with students and teachers were recorded, anonymised and transcribed. Translation from Danish to English was performed when some students talked and wrote in Danish.

The data collected from the different research methods was coded and analysed following a Thematic Network Analysis approach [40] that resulted in the identification of different themes or categories. Firstly, initial codes from textual data were made. Secondly, we identified categories of initial or sub-themes codes to summarise abstract principles. Finally, clusters or global themes encapsulating a main idea were identified [41].

4 Results

Results from the intervention show three themes that provide contextual understanding about the learners, other actors, the learning environment, and the learning outcomes to be considered in the development of learning designs for building Open Data competencies in elementary schools. The themes are (i) competencies and skills, (ii) interesting

and engaging activity, and (iii) authentic activity which is more than an assignment. Firstly, the results focus on fostering skills for the exploration of data to create arguments that lead to concrete solutions, answers or good conclusions about real problems. Secondly, the results show that understanding learners' interests and context is crucial for adapting activities to their needs and increasing their engagement. Finally, creating an authentic environment was highlighted to enhance the relevance and applicability of the learning outcomes, providing students with meaningful opportunities to engage with real-world challenges. Collaboration with other stakeholders, such as experts and community members, was identified as a way to increase authenticity and enrich the learning process by providing valuable insights, perspectives, and opportunities for real-world applications.

Table 5 shows the findings of the qualitative study categorised by themes and subthemes. The findings are presented according to their relevance for students (S) and teachers (T).

4.1 Competencies or Skills

Teachers and students discussed the skills and competencies needed for using data in learning and the abilities for engaging in the OD learning activity. Six sub-themes were identified: Finding the right, relevant and useful data (T + S), connecting data to make a good conclusion or solution (T + S), being critical, creating arguments and discussing with the data (T), seeing a problem (T), answering questions (S), and drawing a story (S). The sub-themes stress the importance of a process for managing or understanding data to find a solution to a problem or question. Teachers and students made explicit that the relevant ability is not just finding data, but finding the relevant data for solving a problem, making a solution, or answering questions. Students in the survey after the test expressed the challenge of "finding credible sources", and "finding information because it isn't just straightforward". Interviewed teachers stressed that "it's about the process of searching by themselves", "if they are critical enough to find the right data and how to use it", "seeing a problem and trying to find the right solution by finding the right data", "use data to discuss with it and argue about their decisions", "how to look in data and learn the analysis paths of it and analysing a lot of data to make a solution or make a good conclusion".

The results in this theme provide an overview of the most relevant skills and abilities at the elementary school level from the whole spectrum of OD competencies.

4.2 Interesting and Engaging Activity

In designing open data learning experiences for elementary school students, it's crucial to maintain their interest and engagement throughout the process. Results show a variety of options that are not exclusive but rather complementary. Six sub-themes show the perspective of teachers and students on ways of achieving interest and engagement. An interesting and engaging OD learning activity might be active and playful (T + S), having a meaningful outcome (T + S), involving students personally in a problem (T), connecting to students' interests and daily life (T), challenging but also fun (S), and gives freedom to students, who are not listening but doing themselves (S). During interviews,

Table 5. Results

Theme	Sub-theme
Competencies and skills	Finding the right, relevant and useful data (T + S)
	Connecting data to make a good conclusion or solution (T + S)
	Being critical, creating arguments and discussing with the data (T)
	Seeing a problem (T)
	Answering questions (S)
	Drawing a story (S)
Interesting and engaging activity	Active and playful (T + S)
	Having a meaningful outcome (T + S)
	Involving students personally in a problem (T)
	Connecting to students' interests and daily life (T)
	Challenging but also fun (S)
	Gives freedom, students not listening but doing themselves (S)
Authentic activity, more than an assignment	Meaning of analysing data in solving real problems (T + S)
	Helping/involving the community around (T + S)
	Bringing in experts from the outside world (T)
	Students being proud of their work (T)
	Students being heard and sharing ideas with others (S)

teachers stressed the importance of assuring a sense of ownership and relevance in students by connecting the learning activity to relevant problems. For example, they mentioned that "I think students need to get involved personally", "global problems might feel distant or abstract to young pupils", "is relevant for the student because they can relate to and is something that (s)he likes and does in daily life" (Teachers during interviews).

Students stressed their desire for more active and playful activities. Encouraging active participation and providing opportunities for hands-on exploration might empower students to take ownership of their learning journey, fostering a sense of autonomy and independence. As it was stressed by students "you just don't sit down and listen to the teacher but do most yourself. You have to figure something out on your own and then have to share it with your group" (Students during focus group).

4.3 Authentic Activity, More Than an Assignment

Results show the importance of ensuring authenticity throughout the learning process which increases its relevance for the students. Teachers and students discussed opportunities for achieving authenticity, "if the students don't feel motivated about the product, they don't find it meaningful then" (T, interview). Five sub-themes present a range of opportunities for increasing authenticity that are relevant elements for students such as finding the meaning of analysis data in solving real problems (T + S), helping or involving the community around (T + S), bringing in experts from the outside world (T), students being proud of their work (T), students being heard by sharing ideas with others (S).

Students might be empowered to grasp the real-world impact of their data analysis efforts, gaining insight into how their skills can make a meaningful difference in solving actual problems. Teachers mentioned that "working with real-world problems helps students to see how useful what they learn is", "I don't think they will see the meaning in analysing data just to solve a school-made problem, they can see the meaning of analysing data and use it to solve some problems" (Teachers during interviews). Helping or involving the community around them might also allow students to see the tangible impact of their work and increase their motivation, as a student mentioned "I usually get easily distracted if the teacher just starts talking and we just have to sit there and listen" (Student during focus group). Engaging with the local community not only enhances authenticity but also promotes active citizenship and social responsibility "authenticity is coming when you can give your free time", and "writing an assignment is different than doing something for a problem" (Teachers during interviews). Moreover, bringing in experts from outside the classroom provides valuable insights and perspectives, enriching the learning experience and connecting students to their local environment.

5 Discussion and Conclusions

The current study explores how learning designs to develop OD competencies in elementary school can be developed and what educational design elements are relevant by applying a design-based research DBR methodological approach. We identified authentic, inquiry and situated learning approaches as important elements for designing impactful Open Data learning experiences based on the central competencies of DL and RWPS. Diving into the context of students and teachers during the intervention in a Danish school, results stress and describe three relevant elements, firstly about the more important competencies as learning outcomes, secondly how to keep students interested, and thirdly, how to increase the authenticity of OD learning activities. This study suggests the development of OD learning designs focused on empowering young students to explore, analyse, and construct arguments using data to propose solutions to real problems. These real problems are close to the students or to their surrounding community. Immersing students in environments resembling authentic contexts and adapting the activities to their interests and backgrounds fosters deeper engagement and relevance. Furthermore, collaborating with external stakeholders such as experts and community members enriches the learning experience by providing diverse perspectives and authentic real-world connections.

Authentic and project-based learning offer robust frameworks for designing meaningful OD educational experiences. Authentic learning stresses the importance of real-world connections and meaningful tasks, while project-based learning encourages collaboration, inquiry, and problem-solving skills.

By integrating elements of game design, such as roles and challenges, OD learning designs can further enhance engagement and motivation within authentic and inquiry-based frameworks. A game-based approach helps to make the knowledge that is abstract and common for OD experts more concrete and embedded in a situation [42, 43].

Rooted in learning theory and the study findings, we propose the development of Open Data learning designs in elementary school as a game design. Both, learning design and game design approaches emphasise the importance of clear goals, meaningful challenges, structured experiences, and interactive engagement in promoting learning and achievement.

5.1 Developing Open Data Learning in Elementary School: A Parallel Between Learning Design and Game Design

We compare learning outcomes to game goals to present a game design for OD competencies in elementary school. The essential elements of game design have been described by Costikyan as five: goal, struggle, interaction, structure, and endogenous meaning [44]. Beetham's learning design approach focuses on creating effective learning experiences by understanding learners' needs, goals, and the context in which learning occurs [34]. Learning activities are designed to help students achieve these goals, providing a sense of purpose and direction like the goal element in game design. Learning activities might present students with meaningful challenges and opportunities to deal with complex concepts and ideas, like the struggle element in game design. While Beetham's approach may not explicitly address internal game mechanics, it does emphasise the importance of designing learning activities with clear structures, rules, and feedback mechanisms. Learning designs provide a framework for interaction and learning like endogenous mechanisms in game design. Beetham's approach involves carefully structuring learning experiences to provide coherence and progression. In comparison to the structure element in game design, the learning activities guide students through the learning journey and help to scaffold their understanding. Beetham's approach recognizes the significance of interaction and collaboration in learning, where students engage with content, peers, and instructors through various modes of interaction, fostering active participation and social learning like interaction in game design. Figure 3 summarises the parallel between Beetham's and Costikyan's approaches.

5.2 A Game Design for Building Open Data Competencies in Elementary School

A role-playing game for building Open Data (OD) competencies involves elementary school students in solving an environmental mystery that uses Open Government Data. Grounded in Data Literacy (DL) and Real-world problem-solving (RWPS), the game builds a narrative where professional data journalists in a local newspaper work on getting, understanding, and delivering data to explain a mysterious event to the community. Students play the role of data journalists who cooperate in groups of 4 people and the

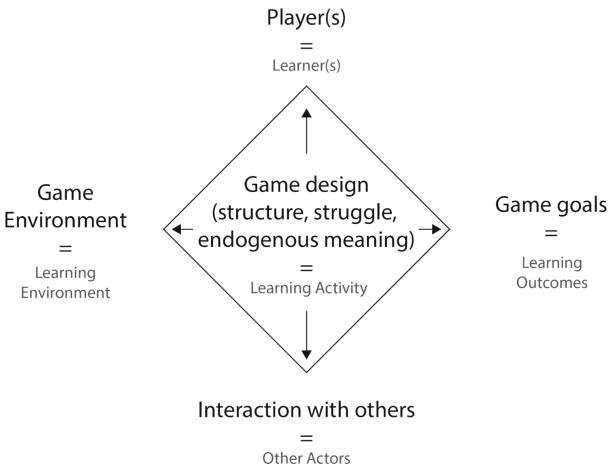

Fig. 3. Parallel between Beetham's Learning Design approach and Costikyan's game design approach. Adapted from Beetham [34] and Costikyans [44]

teacher acts as the newspaper editor to challenge the data that the students' outcome is based on. The game is a simulation grounded in two authentic elements. On the 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 the students act as OD journalists engaging in a simulation of an authentic OD process.

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