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PAPER

Data-Driven School Improvement and Data-Literacy in K-12: Findings from a Swedish National Program

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ABSTRACT

Data-driven school improvement has been proposed to improve and support educational practices, and more studies are emerging describing data-driven practices in schools and the effects of data-driven interventions. This paper reports on a study that has taken place within a national program where 15 schools from 6 different municipalities and organizations are working at classroom, school and municipality levels to improve educational practices using data-driven methods. The study aimed at understanding what educational problems teachers, principals and administrative staff in the project aimed to address through the utilization of data-driven methods and the challenges they face in doing so. Using a mixed-methods design, we identified four thematic areas that reflect the focused problem areas of the participants in the project, namely didactics, democracy, assessment and planning, and mental health. All development groups identified problems that can be solved with data-driven methods. Along with this, we also identified five challenges faced by the participants: time and resources, competence, ethics, digital systems and common language. We conclude that the main challenge faced by the participants is data literacy, and that professional development is needed to support effective and successful data-driven practices in schools.

KEYWORDS

data literacy, data-driven decision making, data-driven education, professional development, ethics, data-based decision making, school improvement

1 INTRODUCTION

In the past decades, there has been a revolution in information technology. With these new technologies, a huge amount of data is generated. This has led to the development of data-driven methods in many sectors in our society, such as marketing, medicine and industry [1–3]. As a consequence, we have witnessed big transformations in society and in the ways we work and live our lives. However, this transformation has not been fully implemented in the educational sector, albeit we see digital technologies in various forms, e.g., learning platforms and digital

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educational resources being frequently used [4, 5]. In recent years, however, around Europe and the rest of the world there has been an increasing interest in developing data-driven methods for schools to transform education, for instance in Spain, Germany, Netherlands and Norway [6]. There are also reports that many countries have developed national policies for data-driven school improvement [6]. In Sweden, there have been few initiatives at the K-12 level focusing on data-driven school improvement. EdTechLnu[1] conducts studies on how digital resources can support all types of teaching and learning. One of the first national programs in Sweden was initiated by Ifous[2] in 2020. The aim of this program is to develop new data-driven methods and increase data literacy for teachers, principals and district-level administrators in Swedish schools. Data literacy has been defined as the educators' ability to set a purpose; collect, analyze, and interpret data; and take instructional action [7].

Data-driven decision making (DDDM) is a practice that has been proposed for educators to use data effectively [8]. DDDM has been defined by Hamilton et al. (p. 46) [9] as "collecting and analyzing various types of data, including demographic, administrative, process, perceptual, and achievement data, to guide a range of decisions to help improve the success of students and schools." Much research has been conducted in order to determine what prerequisites are needed for effective data use, such as leadership and teacher knowledge and skills, to name a few [8].

Many researchers have developed frameworks to promote data use in schools and build capacity for DDDM [10–15]. These frameworks provide guidance for future work in the field. Many of these frameworks are similar to theories of action and determine the steps needed in DDDM, e.g., collect data, analyze data and take actions on the information acquired through data analysis [13–15]. Bernhardt [10] has developed a framework for different categories of data that can be collected in schools. The framework by Ikemoto and Marsh [11] is used to categorize data-driven projects according to whether they are simple or complex when it comes to data use and analysis.

There are a number of studies that focus on the effect of a data-driven approach, especially in math and language, showing that significant improvements can occur as a result of DDDM [16–19]. In a review, Grabarek and Kallemeyn [20] found a positive relationship between data use and student achievement in 38% of the studies, 36% of the studies showed no relation and 26% found a mixed relationship.

Research indicates that effective data use in schools requires multiple sources of data to be effective [21]. Lai and Schildkamp [22] suggest four different kinds of data in education: input data (e.g., student and teacher characteristics), outcome data (e.g., student achievement and well-being of the students), process data (instruction strategies and absenteeism) and context data (e.g., school culture and buildings). This is similar to the framework that Bernhardt [10] suggests for continuous school improvement, which also suggests perception (e.g., satisfaction with student learning) as a data type. In a review by Samuelsen et al. [23], it was found that learning management systems (LMS), student information systems and questionnaires are used in higher education to improve student learning. The most common data type was activity logs, student background information, questionnaire data and performance test data.

An important prerequisite for conducting a data-driven project is data literacy, which can be defined as the educators' ability to implement DDDM [8]. There are also

[1] https://lnu.se/en/research/searchresearch/edtechlnu/.

[2] "Innovation, research, and development in school and preschool," translated from Swedish: "Innovation, forskning och utveckling i skola och förskola" (Ifous).

studies on how to improve data literacy among teachers through interventions [7, 24, 25]. Kippers et al. [7] conducted a data-literacy intervention for improving data literacy for teachers. In the study, five components of data literacy were examined: set a purpose, collect data, analyze data, interpret data and take instructional action. The biggest challenge for teachers was to set a purpose and analyze data. There are also several frameworks that have been developed for data literacy [26, 27].

Research shows that professional development in data literacy can be made more effective within professional learning communities (PLCs). A PLC consists of teachers collaborating with each other and sometimes with other schools [13]. PLCs sometimes work with the data-team procedure, where an external coach works in a systematic and iterative way to solve educational problems in schools [13]. In order to take effective actions, the teacher also needs foundational knowledge in pedagogical content knowledge, curriculum knowledge and knowledge of the learners [28].

Other studies have investigated how teachers work in a data-driven way to improve schools [29–31]. These studies are primarily focused on how schools solved didactical problems and do not consider other areas of school improvement. However, few studies show how teachers, principals and administrative staff plan data-driven projects in K-12 education, which educational problems they address, and what data-literacy skills they exhibit when planning these [11, 14, 19]. Without studying such aspects, we will not have an understanding of current competencies of school personnel, i.e., data-literacy levels and their interests connected to data-driven educational practices.

Therefore, this study focuses on the planning process of teachers and school personnel when they plan a data-driven project in order to see what data-literacy skills they display and the challenges they face in doing so. By adopting such a lens, we can better understand the requirements for successful data-driven practices in K-12 education. The research questions for this study are the following:

RQ1. How do school personnel plan a data-driven project?
RQ2. What data-literacy skills do school personnel exhibit while planning a data-driven project?
RQ3. What challenges do schools face when they plan a data-driven project?

2 METHODS

2.1 Context

This study was part of a three-year-long national research and development program about data-driven school improvement (DDS), conducted by an independent research institute (Ifous). The DDS program involved multiple iterations with research and development being conducted at micro, meso and macro levels [32]. The work at the micro level was performed by groups of teachers implementing data-driven practices in classrooms; at the meso level, by groups of school personnel such as principles, student health teams and ICT teachers investigating general school aspects; and finally, at the macro level, by district level administrators and development strategists focusing on projects from a municipality perspective. Personnel at participating schools and districts formed development groups, depending on which level and activity they had chosen to develop. This study took place during the first year of the DDS program, during which the development groups had formulated problems and developed project plans for data-driven projects according

to their school's needs. DDS participants consisted of personnel working in and with schools from pre-school to upper secondary level. Six school districts participated: four municipality organizers and two organizers of an independent school. In total, 15 schools and 115 participants were part of the project. They were divided into 17 development groups, all of them formed within schools, except for the groups at the district level.

2.2 Participants

Of the 115 participants there were 78 teachers, 3 from student health service, 18 principals, 8 district-level administrator and 8 with other roles. 75 of the participants answered the survey (see section "Survey"), and the age distribution of these 75 participants is shown in Table 1.

Table 1. Distribution of ages

Age	20–29 Years	30–39 Years	40–40 Years	50–59 Year	Above 60 Year
Distribution	1 (1.3%)	13 (17.3%)	31 (41.3%)	21 (28.0%)	9 (12.0%)

There were more females (73.3%) than males (26.7%) participating. Most of the participants had been working for more than 10 years in their current position (60%), while 40% had been working for less than 10 years.

The participating groups worked on different levels and different grades and chose problems that they identified relevant for their school or district. The different groups were labeled according to the theme they were working with: didactical problems (D1-D6), democracy (De1-De4), assessment and planning (A1-A3), and mental health (M1-M4). See Section 3.1 for further details. In Table 2 there is a short description of participating groups.

Table 2. Participating groups

Group	School/District	Problem
D1, Classroom level	Year K-3, Municipal school	This group wants to investigate how they can enhance their students' literacy.
D2, Classroom level	Year 3–4, Municipal school	This school has recognized that there is a difference between how teachers in year 3 and teachers in year 4 assess reading ability.
D3, Classroom level	Year K-3, Municipal school	This group wants to do a mapping about the pupils' abilities in math with material provided by the National Agency for Education.
D4, Classroom level	Year K-3, Municipal school	This group wants to develop educational practice and increase pupils' goal fulfillment by analyzing data collected in the project.
D5, Classroom level	Year 7–9, Municipal school	This school wants to improve its educational practices linked to equivalence and accessibility using data.
D6, Classroom level	Year 1, Municipal school	This group is working with mathematical concepts such as double/half, which they have found students struggle with in school.

(Continued)

Table 2. Participating groups *(Continued)*

Group	School/District	Problem
De1, Classroom level	Year K-6, Municipal school	This school wants to investigate how cooperative learning affects student collaboration and goal fulfilment.
De2, Classroom level	Year K-9, Municipal school	The group wants to create conditions for participation and influence for the students in their school in order to enhance their sense of capacity and ability.
De3, School level	Year K-9, Municipal school	This group wants to investigate if the students get the same amount of speaking space, regardless of their gender.
De4, School level	Year 4–6, Municipal school	This school has recognized that the students do not feel secure in their school and wants to find methods to enhance their feeling of security and belonging.
A1, School level	Secondary school, Private school	In this school, they want to intervene earlier for the students who do not receive a passing grade in different subjects.
A2, District level	Year K-9, School district	A school district wants to investigate how planning, teaching and assessment can be developed in order to improve student achievement.
A3, School level	Compulsory school for pupils with learning disabilities	A school has recognized that students experience subjective assessment, and they are trying to find a way to improve objectivity in their assessment of students.
M1, School level	Year 6–9, Municipal school	This junior secondary school has a problem with absenteeism in their school and wants to find early indicators of problematic school absenteeism.
M2, School level	Secondary school, Private School	This secondary school wants to investigate how students experience well-being and how it is related to education in general.
M3, School level	Year K-9, Municipal school	This school will focus on the students' mental health from K-9 in order to make better interventions.
M4, District level	Year K-9, School district	In a school district, they want to investigate how school absenteeism can be reduced in compulsory school.

2.3 Data collection

This study adopted a mixed-methods approach, to gather data about how participants planned their data-driven projects. Triangulation of data-collection methods (methods 1–3) was used for the analysis (see Section 2.4). In addition, a fourth method was used to validate the results. The data-collection methods were as follows:

1. Written project plans were collected from the development groups
2. A survey was sent to all participants
3. Semi-structured in-depth interviews were carried out
4. A focus-group discussion was conducted to validate findings of data collected in 1–3

The different methods for collecting data will be explained in more detail in the following sections. All 115 participants are represented through the project plans each development group formulated. Out of the 115 participants, 75 participants answered the survey, (see section "Survey") Five were interviewed and 11 were a

part of the member check focus group (see section "Focus group discussion"). The participants' roles in the project were provided by Ifous and are shown in Table 3.

Table 3. Participants' roles in data collection

	Teachers	Student Health	Principals	District Level	Other	Total
Project plan	78	3	18	8	8	115
Survey	44	3	18	7	3	75
Interviews	2	0	2	1	0	5
Member of focus group	8	0	2	1	0	11

Project plan. Each development group wrote a project plan according to their interest and needs. They did so, using a template based on previous Ifous programs and revised by the DDS research group. The participants were asked to describe problem areas; formulate data-driven questions; and describe planned data collection, analysis, communication, decision-making procedures, evaluation, and tools that were to be used, as well as to formulate later potential challenges and lessons learned. The project plans were made available to the researchers. In total, the 17 project plans yielded 63 pages. Data from the project plans were imported into the qualitative software QDA Miner lite v2.0.8 (https://provalisresearch.com/products/qualitative-data-analysis-software/freeware/) for the analysis.

Survey. A survey was administered to gather background information about the participants, e.g., gender, age and work experience. One question was about how the participants assessed their data-literacy skills, which was used to answer research question two. To answer research question three, there was also a question about their perceived challenges within the data-driven project. At the end of the survey, the participants were asked if they wanted to participate in an in-depth interview.

An online service for surveys, named Survey & Report v4.3.10.5 (https://www.artologik.com/en/survey-report), was used to distribute the questionnaires and compile the results. A link was sent by email to the 115 participants, whose addresses had been collected by Ifous. All 75 respondents answered every mandatory question. The dataset collected through the survey was imported to SPSS 27 (https://www.ibm.com/analytics/spss-statistics-software).

Interviews. The sample for the semi-structured in-depth interviews consisted of participants who had shown interest in participating in interview sessions when asked about this in the survey. Among those willing to participate in the interviews, eight participants, strategically chosen to represent each level of the program, were asked to participate. Five agreed to participate; three of the interviewees could not find the time to participate in the interview. The five were distributed as follows: one at the district level, and two principals and two teachers. The interviews lasted between 30 and 44 minutes and were conducted and recorded through Zoom video meetings, after which the interviews were transcribed verbatim according to Kvale [33]. The interview guide had three introductory questions about the interviewee, and thereafter the questions were aimed to better understand the planning process and the areas they focused on, which was used to answer research question one. To answer research question two, we also asked questions related to their data-literacy skills, i.e. skills related to problem identification, collection of data, and analysis. Finally, we asked questions about the challenges the participants had encountered in planning the projects, which were used to answer research

question three. The interview guide was piloted beforehand with two teachers outside of the DDS program.

Focus group discussion. To validate the analysis and conclusions drawn from it based on the three areas of data collection, a focus group discussion was performed. The sample for the respondent validation consisted of eleven leaders of the development groups. One of the researchers gave a ten-minute presentation of the results. Thereafter, the leaders, one by one, answered whether the results adequately described their experience within the program/with the projects. The respondents were also encouraged to add, exemplify, contradict or in other ways enrich the results. The presenting researcher led the discussion, while the respondents' answers were noted by another researcher. The presentation was made available afterwards for participants to give additional feedback or comments if they wanted.

2.4 Data analysis

For the first research question, QDA software was used for thematic analysis of data from the project plans, survey and interviews to identify the problem areas the different groups focused on. Three separate analyses were conducted, and then the different themes were compared to see similarities and differences between the analyses. These three analyses were combined into one thematic analysis. The analysis was based on Braun and Clarke's [34] six-phase analysis. This kind of thematic analysis moves back and forth in the process of reading and coding in order to identify patterns and create semantic themes [34]. First, (1) all the material was read through, and (2) initial coding was performed, which generated a list of ideas for themes. After the initial themes, (3) a more precise coding process was conducted, where the initial codes were generalized and then sorted into themes. (4) The themes were reviewed to ensure coherence and representativeness according to the dataset. Thereafter, (5) the themes were named and defined by describing the essence of each theme. Finally, (6) a report of thematic analysis was produced.

The survey was constructed for several studies within this program, and some of the questions were excluded in this study. SPSS was used to perform and simply report on descriptive statistics about the participants for questions about demographics and self-estimated abilities. SPSS was also used to perform Principal component analysis (PCA) on one multiple-choice question. Results from PCA were interpreted by comparing loading items in the components with previously created themes.

The project plans were used to collect information about what kind of data the different development groups collected. The data was then compared with the categories suggested by Lai and Schildkamp [22] and Bernhardt [10]. The different categories of data are input data (e.g., Age and gender), process data (e.g., Attendance rates and graduation rates), perception data (e.g., Satisfaction and feelings about safety) and output data (e.g., Assessments and well-being of the students).

The second research question was analyzed by creating a coding table based on the work by Gummer and Mandinach [26] and Mandinach and Gummer [27] about the abilities teachers need to be data literate. A within-case analysis according to Mills et al. [35] was conducted. Finally, a cross-case analysis was conducted to compare the results between the different groups [36].

For the third research question, a thematic analysis was conducted to identify the challenges faced by the groups. The thematic analysis was conducted individually on the survey, project plans and interviews, and then the results were compared to distinguish similarities and differences in the different data-collection methods.

2.5 Credibility

The method of this study uses triangulation to increase the credibility of this study. By applying different data-collection methods, the reliability of the procedures was increased. Data from interviews, the survey and project plans were analyzed together to establish credibility in the results, both in terms of scope and depth. Furthermore, respondent validation was used to validate the analysis, thereby confirming the findings of the study [37].

2.6 Ethical considerations

All participants in the program were informed in advance that project plans shared on the platform were open to everyone within the program and used as data collection by the research group. Data from the project plans were collected at the group level and was therefore anonymous. Written information was sent to the participants before individual data were collected (interviews and survey). Participants approved all quotes used in the results from the project plans. Participation in interviews was based on the participant's initiative and was thus voluntarily. Participants were asked to provide informed consent in writing before the survey and verbally before the interviews. The interviewees were also invited to read the transcribed material and approve all quotes used in the results. All individually collected data were processed on secure servers and de-identified after analysis. It was optional to participate in the focus group discussion.

3 RESULTS

In this section, the results from the study are presented in the following way: first, planning of the projects are presented together with the four themes from the problem formulation. Then, data-literacy skills are presented, both the participants' assessed and exhibited skills. Finally, the challenges experienced by the different development groups is presented.

3.1 Planning of project

Thematic analysis revealed four different themes of problem areas addressed by the different development groups in this project, namely: didactical problems (D1-D6), democracy (De1-De4), assessment and planning (A1-A3) and mental health (M1-M4).

The different groups used one, two or three different types of data. The most common combination is input data with another type. The three groups that selected three types of data are trying to find out how students' perceptions affect their learning. Their analyses include differences between boys and girls. The most common type of data is input data and process data, followed by output data and perception data.

The 17 different groups used a mix of digital and analog data. In 12 of the groups, digital data was used, while three groups did not use any digital data. A total of 13 groups used analog data. One of the participants explicitly mentioned the use of continuous measurement of data as a means of longitudinal analysis.

There were five main methods to collect data in the development groups: interviews, surveys, studies of documents, observations and data-system extraction.

There was a mix of tools used by the groups, e.g., student information systems, Google Forms, Google Classroom and different educational resources. None of the groups used tools that were designed to be used in data-driven school improvement.

Didactical problems. For the theme Didactical problems, participants showed a strong focus on different subjects, mainly mathematics and Swedish. These groups want to accomplish a change within the classroom. In the following section, a description of the different projects will be presented.

Table 4 show that all groups in this theme used output data, two of the groups (D2 and D4) also used perception data, and four groups (D2 and D4-D6) used input data. Two of the groups (D1 and D3) used one category of data, two groups (D5 and D6) selected two categories of data and two groups (D2 and D4) selected three categories of data.

In this theme, all of the groups identified interesting problems to address, which could lead to improved practice within the classroom. As can be seen from Table 4, groups D1, D3 and D4 formulated framing questions in order to find out if a change in practice can lead to an increased learning for the students. Group D5 and D6 formulated *how* or *why* questions.

Table 4. Desciription of groups in didactical theme

Group	Problem Statement	Collection of Data	Methods for Analysis	Categories of Data Used
D1	Can improved practice increase literacy and locate subject-specific developing topics?	A computer software called Legi-Lexi will be used to collect data together with different assessments.	They did not give any example of methods for analysis.	Output data
D2	To understand the difference between reading objectives in years 3 and 4.	They will collect passing grades, assessments and surveys as data.	No clear statement about analysis except that the results will be analyzed within six months.	Input data Perceptions Output data
D3	Can Numicon increase students' mathematical knowledge?	Assessments will be used as the source of data in this project.	They will analyze these assessments to investigate student progression.	Output data
D4	How can lesson design affect students' results?	Data will be collected through mapping, assessment and surveys.	The data will be analyzed according to gender and language.	Input data Perceptions Output data
D5	When and why do students lose strategies for mental arithmetic?	Assessments will be used as data in this project, together with student background data.	They will compare boys and girls in order to determine if there is a difference between genders. Another comparison will be conducted between different grades.	Input data Output data
D6	Why are some mathematical concepts difficult to understand for many of the students?	Oral assessments will be used as sources of data.	The results from assessments will be analyzed in regard to gender, students' native language and what class year they are enrolled in.	Input data Output data

Groups D1 and D5 will rely on assessments as a single method to collect data. The other three groups will combine assessments with other methods for data collection, mainly surveys.

Groups D4-D6 want to analyze the results to see if there is a difference between different groups, e.g., gender. Groups D1 and D2 have rather vague or no description of their method for analysis. None of the groups have mentioned what methods they will use to analyze the data collected in this project.

Democracy. Some of the project groups focused on democratic values, such as equality and influence. Several groups also made connections to goal fulfillment; they wanted to see if a more democratic way of working could influence student results. These groups are working at the classroom or school level.

Table 5. Desciription of groups in democracy theme

Group	Problem Statement	Collection of Data	Methods for Analysis	Categories of Data Used
De 1	How can cooperative work develop student participation, and will this affect goal fulfillment?	In their work, they will collect data as surveys, students interview and classroom observations.	They will summarize the results in Excel and use bar charts to analyze the results.	Process data Perception data
De 2	What effects can we have on students' learning if they experience influence?	This group will use surveys and interviews to collect data.	They have not described any method for analyzing the data.	Perception
De 3	How is the amount of spoken communication distributed between genders in the classroom?	The project group will use surveys and classroom observations as data collection.	There is no description of how the results will be analyzed.	Input data Process data Perception data
De4	Do group-strengthening exercises affect students' sense of belonging in the classroom?	In their project, they will use surveys, notifications and student information systems to collect data.	The analysis will investigate if there is a difference between boys and girls and if trends develop over time.	Input data Process data Perception data

Table 5 shows that all of the groups will use perception data, two groups will use input data and one group will use process data. None of the groups will use output data. One of the groups (De2) selected one category of data, and three groups chose two categories of data or more.

All of the groups in this theme are working with relevant problems to improve democratic values in school. As can be seen in Table 5, two groups, De1 and De3, are asking "how questions" in their problem formulation. The other two groups are trying to find out if a change in practice will have an effect on students' sense of belonging and their participation.

Surveys and interviews are the most common methods for collecting data in this theme, and all of the groups are combining different methods for collecting data. Two of the groups (De2 and De3) have not described how they will analyze the results, and the other two have a basic description of their methods for analysis.

Assessment and planning. These groups focus on how to improve assessment and how to plan their work with the students. All groups are working on school or district level. They believe that this can lead to improved student achievement.

From Table 6, it can be seen that two of the groups (A1 and A2) in assessment and planning will use a combination of process data and output data, while the third group will use process data as a single source of data.

Table 6. Desciription of groups in assessment theme

Group	Framing of Problem	Method to Collect Data	Methods for Analysis	Categories of Data Used
A1	Improve the individual efforts we make for students to achieve goals regarding qualifications.	Assessment and statistics about how many students who do not receive a passing grade will be used as data source.	Their analysis will be to identify students who need an intervention.	Input data Process data Output data
A2	Improve teachers' planning processes with the support of curriculum changes.	Their collection of data will be surveys, teacher planning, interviews and classroom observation.	In the analysis, they will use keywords and indicators to find evidence for their question.	Process data Perception data
A3	Achieve an objective assessment of students in knowledge and goal fulfillment.	In the project classroom, observation and surveys will be used for data collection.	Data will be analyzed to investigate if assessments are more objective.	Process data

All groups have a problem framing how practice can be improved through assessments and planning. The framing of the problem is not very specific: they do not state what they want to improve or how much they want to improve, there is only an indication that they want to improve.

All groups combine different methods for collecting data; two of the groups (A2 and A3) will use classroom observation as data collection method. All of the groups have a basic description of their analysis and can describe what they want to accomplish with their analysis, but they have not stated what methods they will use to analyze their data.

Mental health. Four groups are working with students' mental health and absenteeism at the school level. The purpose of these project plans is to find ways to follow the students' mental health and to find markers that can indicate that a student needs intervention, due to either mental health or absenteeism.

The most common data category in mental health is process data, which will be used by all of the groups as can be seen in Table 7. Two groups (M3 and M4) will use perception data, one group (M1) will use output data and three groups (M1, M3 and M4) will use input data.

All of the groups in this theme have identified relevant problems, and in their framing questions, they are trying to understand the reasons behind school absenteeism or reduced mental well-being among the students.

Table 7. Desciription of groups in mental health theme

Group	Framing of Problem	Method to Collect Data	Methods for Analysis	Categories of Data Used
M1	What are the reasons for problematic school absenteeism and how can this be reduced?	Most of the data will be collected through mappings of absenteeism and absence data from their school information system.	They will analyze the collected data in order to find reasons behind absenteeism.	Input data Process data Output data
M2	To what extent is our education designed from a health perspective?	This group has many different kinds of data they want to collect, but they have not decided exactly what kind of data they will use for this specific project, but they will use surveys.	The data analysis has not been decided either; this will be done after the decision about data collection.	Process data
M3	How can students' well-being be followed continuously in a data-driven way?	This group will use a survey to collect data among the students, and they will also conduct student interviews.	They will make a thematic analysis of the interviews, and they will analyze the interviews on the difference between gender and school years.	Input data Process data Perception data
M4	Can we see a connection between students' sense of security and absenteeism?	They will collect absence data and experience of support in school through a survey.	The result will be analyzed at the class and school levels.	Input data Process data Perception data

These four groups used mainly surveys, mappings and student interviews to collect data, and all of them will combine different methods to collect data.

One of the four groups (M2) has not decided how it will analyze their results, and the others have a basic description of methods for analysis, e.g., a comparison between boys and girls. One group has named a method for analysis; the other group has not mentioned a specific method for analysis.

3.2 Data-literacy skills

This section presents the participants' assessments of their data-literacy skills together with the data-literacy skills exhibited by the participants when planning their projects.

Understanding of DDDM. Table 8 presents the result from the survey on the participants' perceived competencies (i.e., data-literacy skills) in relation to DDDM.

From Table 8, it can be seen that the participants assess their ability to be between "fair" and "above average," with the highest scores on "follow up and evaluate implemented measures." The lowest score was the participants' ability to formulate a data-driven question.

Table 8. Participants' assessment of their data-literacy skills in relation to DDDM

How Do You Assess your Ability to...	Poor	Below Average	Fair	Above Average	Good	Average (SD)
... develop teaching or school practice in a data-driven way?	5	4	33	30	3	3.3 (0.76)
... formulate a data-driven question?	4	11	36	22	2	3.1 (0.80)
... analyze and interpret data?	3	7	18	37	10	3.6 (0.99)
.... act on performed analysis?	1	6	16	46	6	3.7 (0.75)
... follow up on and evaluate implemented measures	1	5	19	42	8	3.8 (0.75)

Data-literacy skills exhibited by the groups. All groups have identified relevant areas in their data-driven projects, which have a potential to improve the quality of instruction and processes in their school or district. The groups have tried to frame the question so it can be used in a data-driven approach. There are several groups (D4, D5, D6, De1, De3 and M3) that are asking *how* questions or *why* questions in an attempt to understand something about their school or district. There are other groups (D1, D3, D4, De2, De4 and A1-A3) that want to investigate if a change in practice will lead to an improvement in their school or district. There are some groups that are trying to find connections between variables, e.g. mental health and school absenteeism, and two groups (M2 and M3) that want to find indicators so they can intervene at an earlier stage. In the focus-group discussion, it was clear that all of the participants wanted to make a change in their practice but had different ways of getting there. The framing questions posed by the groups are not very specific; many of the groups have not explicitly indicated what kind of change they want to accomplish. There are many groups that want to accomplish better results but have not stated the current situation or what the future situation will look like. Furthermore, none of the groups in this program has measurable goals in their framing of the question. In the interviews, many participants declared that they found it difficult to frame the question; they think it is difficult to narrow down the problem so that it can be used in a data-driven approach.

Two groups (D1 and D5) have one method to collect data, and the other groups use two or more different methods. Only one group has indicated that they will

collect data continuously in order to see trends over time. Many groups have selected relevant sources of data, but in the interviews and project plans, many participants raise concerns about how to ask relevant questions. There is an uncertainty in many groups if their questions will provide them with the answers they need. Many participants also discussed whether students and teachers would make a correct interpretation of the questions, especially survey questions, in their data collection. In the interviews, many participants express an uncertainty about what kind of data they should use for their project, i.e., what kind of data they should collect in order to learn more about the problems faced by the group.

Five groups (D1, D2, De2, De3 and M2) have not stated that they will analyze the data, and many groups state that they will analyze the data but give no indication of what methods will be used. There are several groups (D3, D5, A1-A3 and M1) that have a clear purpose of what they want to achieve with their analysis, but they have not described how the analysis will be conducted. In the interviews and during the focus-group discussion, many participants expressed an uncertainty about how to conduct analysis and what tools they will use. Several participants also express concerns about their own ability to use different tools for analysis, e.g., Excel.

3.3 Challenges

There were many different challenges faced in the projects, and the following themes were found: time and resources, competence, ethics, digital tools and common language.

Time and resources. There are many aspects about resources; many groups find it difficult to find the time to work on their project. Others think that it will be difficult to maintain focus for three years; they are afraid that other projects would be prioritized. One of the principals talks about the time aspect:

> *"Then there is the time aspect. I think it's going too slowly. I'm always in a hurry, so I think there's a lot of talking. Now we should try this, and now this, and I don't like it. I guess it's going too slowly. It will be three years, and then I think that it may take three years then."*[3]

Other groups are uncertain about what resources are available for this project. Different groups mentioned different aspects, but some lacked relevant literature or assessment material.

Competence. Many participants also have problems understanding the concept of DDDM, what is new and how it differs from traditional school improvement: How can new digital tools be used to gain knowledge that is not available with traditional methods? Another challenge faced by the groups is narrowing the scope of the project and making it too big.

> *"There have been different challenges for different groups. It is difficult to formulate questions that really make you get answers to what you want to know. Then it is difficult when formulating a question method to be sure that you have chosen a method that actually answers what you are wondering about."*[4]

[3] Excerpt from interviewee 2 (translated from Swedish).

[4] Excerpt from interviewee 5 (translated from Swedish).

Several groups are concerned about their ability to formulate a problem that can be answered in a data-driven way, as shown in Section 3.2, as well as experience regarding data analysis. One of the principals stated that there tends to be a focus on storytelling or just repeating what is stated in the data and not on finding the reason behind the results when teachers analyze educational problems.

Access to data seems to be something of a paradox. There is plenty of data that can be used, but several groups state that it is difficult to find the right data for their project. There is also uncertainty about which data should be used to get a good analysis. In the interviews, several respondents discussed the problem of structuring the data and making it accessible to everyone who needs the information provided by the data.

Ethical issues experienced. Some project participants have a very strict policy on the use of student data, while other participants have a more liberal policy. There are some tools that could be useful for data-driven school improvement, but since they store data outside of the EU, the use of these tools in Sweden is not allowed.

Digital systems. Many different systems used by the organizers contain data that could be used for data-driven school improvement, but according to the participants, it is difficult to access the data that the project groups need to solve their problems. Sometimes the data exists in the administrative school information system but it is not possible to retrieve it at a group level. In one of the schools, the students belonged to several different classes, but the system allowed the students to belong to only one group. Several groups also expressed concerns about their ability to use tools that could be used for data collection and analysis. Other groups discussed the problem with data that is available in different systems but is not accessible to the teachers—at least not in a way the school wants them. This makes it difficult to conduct relevant analysis within the projects.

Common language. Several participants have discussed the problem of the lack of a common language. In their discussions, it is clear that different concepts have different meanings for different teachers. One of the groups stated that it takes a lot of time to agree on common definitions instead of conducting analysis. In the project plans, there is a difference in how language is being used when describing the problem formulation. Some of the groups provide a clear definition of the problem, while other groups have a vaguer description. One of the principals noted that this is one of the biggest challenges for the different groups.

4 DISCUSSION

During the last decades, schools around the world have started to implement data-driven methods. Some initiatives are based on the national curriculum, and others are initiated at a local level [4, 18]. The purpose of this study was to understand how teachers plan a data-driven project, what data-literacy skills they display and what challenges they encounter. Many studies have examined single interventions, but this is one of few studies that report on a national project in which data-driven improvement interventions are conducted at micro, meso and macro levels. This study has also shed some light on what kinds of skills teachers and other school personnel need to develop in order to work effectively with local problems in their schools and districts.

For the first research question, a thematic analysis was conducted, and it revealed four themes that participants in the national project focused on in the first year of

the project—namely, didactical problems, democracy, assessment and planning and mental health. None of these problems is new to schools, and the project groups are trying to solve these old problems with new methods. There is an anticipation from the participants that these data-driven methods will lead to a better understanding of these problems through systematic collection and analysis of data that will reveal patterns that are not possible to see with traditional methods.

However, there is a narrow selection of tools to collect data with, which indicates that the groups use the tools that they are familiar with, and not the tools that might be better. One possible explanation for this is that the groups are not aware of different tools and how they can be used for data-driven school improvement. Another explanation is that the groups do not have the right competence to use these tools, as expressed by some participants of the program. This corroborates with previous studies that have shown that technical skills are a prerequisite for successful implementation of DDDM [8].

Previous studies on teachers' use of data have shown a focus on didactical questions, professional development of teachers, absenteeism, mental health, goal fulfillment, school organization and changes to the curriculum [11, 18, 38]. In this study, we have identified one new area that schools address with a data-driven approach: democracy.

Our second research question was about what data-literacy skills the participants exhibited. According to our analysis, all of the groups identified relevant problems for their school, and this is essential for a successful data-driven project [27]. There are many schools that have problems in framing the problem so it can lead to a decision and subsequent action [27]. Some of the problem formulations are vague and some are wide in their scope which can make it difficult to decide about the problem [19]. This finding is in contrast to the framework developed by Mandinach and Gummer [27], where identification of the problem and framing the problem were considered as the same skill.

Research also indicates that schools need to use multiple sources of data to achieve effective data use [22]. In the DDS program, there was a big variation in how groups use data. Some groups collected data from multiple sources while other groups had a more limited selection of data. This is important because it is not enough to rely on one data source if the problem is to be accurately understood [21].

This study has shown that the participating teachers have limited knowledge about different methods and tools for analysis of data. There are rather vague descriptions or no description of different methods, which can be a limitation for their data-driven project. This finding corroborates previous studies that have shown that teachers find it difficult to analyze and interpret data [7, 23].

Our findings show that there are many central data-literacy skills that need improving. This finding corroborates previous studies that have also identified limitations in data literacy and digital competency as a central challenge for successful data-driven school improvement [7, 25].

In addition to the above-mentioned challenge, we note that several groups raised ethical questions related to data collection, such as what kind of data can be used and how it could be combined in an ethical way. Some groups use anonymous data collection, which makes it difficult to combine different kinds of data. There is a difference in the ethical policies among different school organizations, where some adopt very strict policies and others do not, which in turn could lead to inequality between schools. Slade and Prinsloo [39] discuss the moral responsibility for institutions to use relevant information in order to provide effective support for

the students. Mandinach [40] states that this is part of being data literate: to know how to use data and to protect student privacy at the same time.

Our study also shows that many teachers lack a common language. Sykes et al. [41] have argued that common language is a necessary skill for teachers in school development. There are two aspects of common language that are important for school improvement. The first is to have common definitions of concepts used in school, and the other is to use common language as a means to identify, problematize and solve problems of teaching and learning [41]. In this study we see several groups that use language to investigate their problems and discuss possible solutions. There are also groups that state what they want to do without reflection or problematization. This could be an indication of how well the group understands and addresses their problem.

None of the groups discussed data-use culture, collaboration or leadership as a challenge for their project, which were identified as necessary prerequisites by Hoogland et al. [8]. This could be due to the early stage of the project and that several of the groups have not yet encountered these aspects or have not been aware of them.

4.1 Implications for practice

This study reveals a need for professional development for teachers and principals in data literacy. One of the challenges is to frame the problem and identify which data types can be used for data-driven school improvement. Several projects also face the challenge of having broad non-narrowed scopes, which require large datasets from different sources of data and which may complicate the analysis and interpretation of the results. Our recommendation is therefore to start with small and well-defined projects that can give results that will make it possible to gain experiences, competencies and the data-literacy skills required for larger projects. We also recommend using simpler analysis methods as a start, such as color coding and simple visualization. More advanced methods can be introduced at later stages, when the participants have developed data-literacy skills and experiences.

We also recommend that teachers and principals explore digital tools as a means to collect and analyze data. This will make the collection and compilation of data much easier and make it possible to see trends over time and reveal new insights to the problems faced by the schools. When this is accomplished, teachers can truly take advantage of the new technology and work on local problems for systematic and continuous improvement.

4.2 Implication for policy

Most of the participants in this study demonstrated limitations in data literacy and digital competence for data-driven school improvement. Against such a background, we suggest that improving data literacy for school personnel should be a part of national strategies for schools. An increased use of data can generate information and knowledge, which can be used for future educational reform and as a means to link local school development with national reforms.

Furthermore, there are over 600 different organizers of schools (both public and private) in Sweden, and there are many different interpretations of how to use data in an ethical way and according to GDPR. It is therefore necessary to develop

national guidelines on data use for school improvement to ensure equality between schools—for example, as national guides for data usage of UK [42].

4.3 Further studies

This study has focused on the planning process in schools, and further studies are needed to see what effects data-driven interventions will have in schools. What can schools learn from an intervention? Will an intervention contribute to better developed data literacy among teachers and principals? It would also be interesting to investigate the most effective interventions for improving data literacy for school personnel. In this study, we noticed that teachers and other school personnel use data and digital tools in different ways. Therefore, it would be interesting to study how teachers' perceptions of digital tools affect the decisions they make about projects.

4.4 Limitations of this study

Fifteen schools agreed to participate in this program, possibly displaying a greater interest for this domain than in general. Consequently, it is difficult to draw general conclusions about Swedish schools, even though the sample is relatively big. Furthermore, this study took place during the COVID-19 pandemic, which could have an impact on the results, as many schools reported that it was difficult to prioritize this project while considering the obstacles posed by the pandemic. The survey was distributed early in the project, at a time when many participants had not yet decided what kind of project they wanted to conduct. Consequently, several survey questions were excluded from the analysis.

5 CONCLUSIONS

This study studied how six different municipalities and organizations working at the classroom, school and district levels plan a data-driven project, what data-literacy skills they exhibit and what challenges they face in doing so. The thematic analysis revealed four areas that the groups used for school improvement: didactics, democracy, assessment and planning and mental health. All of the groups defined areas that could be investigated in a data-driven approach. Our study also shows that many groups had problems framing the problem so it could be used in a data-driven approach. We also see a challenge in analyzing the data, as multiple planned projects had rather vague or no ideas about how to analyze the results. There were also many groups that had limited understanding of how digital tools could contribute to data-driven school improvement. We can therefore conclude that the main challenge posed by the groups is data literacy and that schools' need for support in implementing data-driven methods for school improvement.

6 DISCLOSURE STATEMENTS

No potential conflict of interest was reported by the authors.

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