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CROWD SCIENCE INFUSED LEARNING: CONNECTING ONLINE TEACHING AND CROWD SCIENCE IN THE SOCIAL SCIENCES

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ABSTRACT

In this article, we reflect upon the combination of crowd science and online teaching, which we refer to as Crowd Science infused Learning. We discuss Crowd Science infused Learning's conceptual design and its viability in sociology and related disciplines. For this purpose, our research project 'Data Traces' serves as an empirical case. In the project, we developed an online platform that provided a 45-minute teaching unit, training students in using different forms of digital data: websites, newspaper articles, and administrative register data. Afterwards, students were assigned to predefined, small-scale research tasks contributing to a real-world research project on the social relations in entrepreneurial groups. By completing the tasks, the students could apply their knowledge, gain insights, and contribute actively to an ongoing research project. This combination links students' learning experience with the collection of data for research purposes. We also implemented game elements in the platform's design to support students' motivation. After a brief outline of the Data Traces Project's chronology and key conceptual decisions, the article focuses on a critical discussion of the combination of crowd science and online teaching. Despite significant challenges, we believe that Crowd Science infused Learning is a promising approach and identify opportunities and conditions for a successful combination of crowd science and online teaching.

Keywords: citizen science; online learning; blended learning, digital sociology.

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1 INTRODUCTION

Since its beginnings, digitalization has been linked to the postulate that it would enable new forms of social participation and thus ultimately contribute to a democratization of many aspects of our social life (Dickel & Franzen, 2016; Marres, 2018). However, this was not empirically realized. It became apparent that the establishment of digital infrastructures instead led to a gradual expansion of the traceability, analyzability, and manipulability of participation (Marres, 2018, p. 158). While the cultural and political ideal did not materialize, the concrete forms of participation possibilities changed (Marres, 2018, p. 158).

These changes impact the field of science and lead to the question: what is the digital future of the social sciences (Halford et al., 2013) and the associated demand for a 'digital sociology' (Marres 2018). The new modes of participation are relevant for sociological research in two ways: on the one hand, they produce new data on the participation of individuals in societies, and on the other hand, they open up new possibilities for participation in the production of knowledge about societies (Marres, 2018, p. 159). A specific mode of this knowledge production is called crowdsourcing, citizen science, or crowd science; in the following, we refer to crowd science. Following Franzoni and Sauermann (2014), crowd science methods usually have two characteristics: participation in a project is open to a large number of possible participants, with intermediate inputs (such as data or codes) being made available for these participants to work on. Crowd science in this sense may be understood as a specific type of online-organized citizen science. It focuses on the aspect of contribution of research participants in the form of data collection or classification. Well-known examples of such crowd science approaches can be found mainly in the natural sciences, e.g., 'Foldit' or 'Galaxy Zoo'. This procedure also has been applied several times in the digital humanities (Dickel & Franzen, 2016; Franzoni & Sauermann, 2014).

Current crowd science approaches focus primarily on a logistical aspect of participation: participation in science is organized via a digital platform, thus opening new dimensions of scalability and outreach. Participants are expected to take on pre-defined knowledge tasks of which the content and horizon have been previously defined by a scientific research team (Dickel & Franzen, 2016). In this respect, they are understood as knowledgeable subjects, but they are not expected to make an active epistemic contribution to the accumulation of knowledge (Hackley, 2013). Thus, the participants are integrated as research workers, but less as authors of new knowledge (Marres, 2018, p. 168). In all, crowd science methods can help make previously inaccessible knowledge resources accessible. The opportunity to participate directly in current research has a motivating

effect (Franzoni & Sauermann, 2014, 11ff). Simultaneously, crowd science methods pose organizational and technical challenges. It is necessary to bring together the relevant projects and people willing to participate and motivate them to define tasks and integrate participants' contributions (Franzoni & Sauermann, 2014, 13ff; Scheliga et al., 2018).

Crowd science can also be a valuable learning experience for the participants (Vallabh et al., 2016).This experience is not limited to the research object but extends to participating in the research process itself. Participants are given insight into a pre-formulated research question, the selected data material, how the data was collected, the quality of the data, the processing of the material, and, in some cases, the results obtained. Participation in scientific knowledge production in the form of crowd science, therefore, includes a didactic aspect. In fact, this aspect very much resembles ideas of inquiry-based learning, a specific didactic method often applied in the social sciences in which students can actively place themselves within a research situation (Atkinson & Hunt, 2008; Pedaste et al., 2015). However, the didactic component in crowd science needs moderation in order to grow into a digital version of inquiry-based learning.

In this article, we suggest that by coupling crowd science and online teaching, a digital version of inquiry-based learning can be created, which we refer to as Crowd Science infused Learning. Crowd Science infused Learning opens new opportunities for research and for teaching. Learning through research aims to awaken and train students' scientific curiosity, ability to reflect, and methodological-analytical thinking (Huber, 2014; Pedaste et al., 2015). This digital variant of inquiry-based learning can be flexibly integrated into different course formats and be anchored in university teaching. At the same time, Crowd Science infused Learning offers scalable access to conduct various types of research and to process various types of data. In our Data Traces Project, we explored precisely this connection between crowd science and online teaching. Specifically, we developed a platform on which students were trained to handle digital data and subsequently deal with such data in a research assignment. The task was linked to an ongoing research project to which the students actively contributed through a crowd science approach.

We use our experience from the Data Traces Project as an empirical case to reflect on the connection between crowd science and online teaching, i.e., Crowd Science infused Learning, and its viability in social research. As Bonney et al. (2009) observe, “developing and implementing public data-collection projects that yield both scientific and educational outcomes requires significant effort.” It is the goal of this article, to introduce our approach of Crowd Science infused Learning and to critically highlight the challenges in designing both for research and didactic

outcomes simultaneously. On the grounds of our empirical project, we derive conditions and give indications of central decisions necessary for the design of such a digital version of inquiry-based learning. We suggest that Crowd Science infused Learning requires strong support through teachers as intermediaries, a fit with the local teaching context and the formulation of a task that takes learning and research effects equally into consideration. Although we recruited fewer participants than we had hoped for, we suggest that the current push towards digitalization of teaching and learning under the pandemic makes Crowd Science infused Learning a digital variant of inquiry-based teaching even more attractive.

2 INTRODUCING CROWD SCIENCE INFUSED LEARNING

2.1 The didactic aspects of Crowd Science

For the discussion of a didactic aspect of crowd science, we can draw on insights from previous research into the element of learning in the vast field of citizen science. Indeed, citizen science is often seen as a tool to foster science knowledge and scientific literacy in the general population (Bonney et al., 2009; Trumbull et al., 2000). Scientific literacy may be broken down into several components, such as general science knowledge, scientific processes and methodology, but also expert knowledge about a specific field of study (C. Phillips et al., 2018). However, learning may go beyond the scientific literacy and various typologies and frameworks exist to classify the content of what may be gained and learned through participation in a citizen science project (Jordan et al., 2012; T. Phillips et al., 2018). For example, participation may result in a better understanding of the specific topic under study (topic knowledge), and skills to fulfill the requested research task (such as collecting and interpreting data or classifying information), but also general skills and knowledge, such as computer skills, writing experience, and general digital literacy as well as other generic knowledge (Aristeidou & Herodotou, 2020).

Findings into the learning effects of citizen science remain inconclusive, however. They may also differ between projects conducted offline in the field or online trough digital means (Aristeidou & Herodotou, 2020). Crall et al. (2013), for example, found improvements in science literacy and knowledge when using context-specific measures in an offline project targeting invasive species. Masters et al. (2016) report a positive relationship between forms of active engagement with Zooniverse projects in a project specific science knowledge quiz, but no relationship with general science knowledge. In an experimental study of learning in an online citizen science project, J. L. Dickinson and Crain (2019), find that

volunteers showed increased content-learning, even though this was more a result of an overall interest in the project rather than the outcome of active participation. As Philips et al. (2018) put it, "most projects have yet to document robust outcomes such as increased interest in science or the environment, knowledge of science process, skills of science inquiry". This lack of suitable research into the learning effects of crowd and citizen science is even more pressing in the social sciences where learning experiences may differ from the natural sciences. The topics being studied are quite different and the approaches to research may also be very different, beginning from the data sources to the ways of extracting and analyzing the data that has been collected. Hence, learning experiences participants make due to their research participation may vary as well.

There have also been a couple of instances where citizen respectively crowd science has directly been integrated into the teaching of students in higher education settings (Karlin & La Paz, 2015; Mitchell et al., 2017; C. Phillips et al., 2018). Crowd science, in this context, is a means to fulfil a didactic goal, which is somewhat different from how learning is conceptualized in the above-mentioned studies of citizen science, where learning happens as "byproduct" of fulfilling the research task. It allows to align the participatory aspect of research with didactic goals defined in the curricula of university courses or other educational institutions. Despite these attempts, the idea to implement citizen or crowd science directly in the context of formal curricula in higher education together with students and teachers at a university is still in its infancy. Moreover, research into learning effects of citizen and crowd science in the context of formal higher education is lacking (Aristeidou & Herodotou, 2020). The research that exists seems to suggest that students enjoy this form of hands-on science education (C. Phillips et al., 2018; Ryan et al., 2018). Mitchell et al. (2017) report their offer of combining of university teaching with citizen science to first year students as an authentic research experience and an opportunity to broaden their environmental and scientific knowledge. Students self-reported increases in topical knowledge on indigenous species as well as more awareness for the process of data analysis, presentation, and scientific publication.

We suggest that the didactic aspect of crowd science in higher education could be expanded and thereby increase learning effects. For such a didactic framing of crowd science, an online teaching format is intuitively suitable (Clark-Ibáñez & Scott, 2008; Driscoll et al., 2012; Kergel & Heidkamp, 2016; Pearson, 2010). We refer to the connection of online-learning and crowd science as Crowd Science infused Learning. Student-Learners use a digital infrastructure to flexibly consume knowledge units in terms of time and place (Carliner and Shank 2008; Kepser 2010). These online-learning units not only convey knowledge, but also prepare the

students for the learning experience resulting from the active participation in research; they sensitize students to the research process and its context and qualify them for the task at hand. Such an online teaching unit allows - at least in theory - to maintain the inherent demand for scalability and fits into the corresponding digital platform environment.

Crowd Science infused Learning allows students to participate in solving an authentic research task and thus offers a digital variant of inquiry-based learning. Students immerse themselves in parts of the research process – they have to adopt the research question, conduct data and critically reflect about the quality of the data. As such, Crowd Science infused Learning has the potential to foster research and problem-solving competence. In difference to classic formats of inquiry-based learning in the social sciences, which often take the shape of a full-course, Crowd Science infused Learning has a shorter duration and can be added on or plugged into an existing curriculum. The teachers become providers of digital knowledge units, topics, and search requests and take on the role of contact persons and moderators for the online community. The questions of defining the boundaries of a task and organizing participation are different since it is now necessary to create a connection between the teaching unit and the research task, integrate very different motivational backgrounds, and finally implement the learning and research possibility technically. Ideally, the positive effects of crowd science can add to learning effects, and participants can benefit from the experience of applied research. In the worst case, participants feel overstrained by the additional learning effort. A feeling of exploitation may arise, especially if their own interests and learning success do not outweigh the required cooperation (Euler, 2005). In the next section, we offer a brief chronological outline of the Data Traces Project in order to present our empirical basis for the following discussion of a connection between crowd science and online teaching.[1] The following critical discussion of the implementation of Crowd Science infused Learning in the Data Traces Project, not only emphasizes the promises and challenges of this approach, but also allows to derive key conditions under which Crowd Science infused Learning can be successful.

2.2 The Data Traces Project

We conducted the Data Traces Project from 2017 to 2019 as part of a research group on entrepreneurial group dynamics based at the sociology institute of a major German university. The idea for this project was born several years earlier and represented a potential solution to a pragmatic research

[1] We hope that future applications can benefit from our experience and therefore provide a detailed project report on our website https://www.datenkunde.org/, our platform as an illustrative object as well as the resulting instructional videos, the latter can be used in teaching after consultation.

problem: information on entrepreneurs should be researched from different sources available publicly and online (e.g., company websites, newspaper articles, social media, and registry data) and then combined into a robust data set. Even in times of computer-assisted procedures, automation of such a demanding task is only possible to a limited extent due to non-standardized formats and the need to interpret the data. Therefore, we planned to realize the task using a crowd science approach. Simultaneously, this task is suitable for understanding the special features of digital, process-produced data, such as reflecting on their quality and usability for social science research and learning research techniques. Thus, we defined students of the social sciences as 'crowd' for this task and made Crowd Science infused Learning the subject of a separate project, which explored crowd science as a form of digital and inquiry-based learning.

At the beginning of 2017, we initially focused intensively on the collection and reliability of a wide range of process-produced data. In a pilot study, we were able to use case studies to test how different sources and data formats were beneficial for our case research. We have experimented with different access routes and research techniques and consulted experts in law for data protection and ethical research guidelines. Simultaneously, we offered seminars on 'process-produced data', in which we critically examined the different types of data, their contexts, and suitability for research together with students. In these seminars, we informed them about our plan to create a platform of our own to combine crowd science and online teaching, working with them to design a research task. The student feedback about their learning experience was essential for the task's final design. At the beginning of 2018, we developed and produced a video-based teaching unit, which proved very time and resource consuming. For the seven videos, which eventually comprised 45 minutes, several months were spent writing the script, designing, producing, and editing the videos.

Meanwhile, we created the technical foundations for our crowd science platform. A market review showed that no existing platform solution could integrate instructional videos, assign tasks randomly, and enter information. Therefore, we used and adapted a web-survey panel software and developed a multi-level website as the user interface in an elaborate process. Several months were invested in the creation of the website. A functional platform was available in the summer of 2018. The platform was tested intensively and revised based on the feedback of two consecutive focus groups.

The final product functioned as follows: students could inform themselves about the project on a specially created website and register if they were interested. This initial step was followed by a 45-minute video-based online teaching unit on the topic of digitally process-produced data. The students then selected a research case and received information on the

names of people who have collectively founded a company. The task was to research the social relationships between these people on the company website and in newspaper articles. The sources and information found should then be entered into a corresponding' data entry form'. Organized as a competition, they received points for their researched information. The students with the most points won cash prizes according to their ranking, with a total of € 3,000 prize money.

We began to advertise for our platform in autumn 2018 with a project booth at the German sociology association's congress. There, teachers and students could inform themselves about the project and try out the platform directly on a laptop. Subsequently, 150 chairs in sociological methods and entrepreneurship were contacted by mail. After that, we followed up in two rounds - via e-mail and telephone - to further explain our project. Meanwhile, press releases and news feeds on our university's social media channels were published. We also personally presented the project in lectures at four local universities. We had conversations with lecturers who showed great interest in integrating of the platform into their teaching. We also distributed flyers and hung up posters at local higher education institutions to address students directly. Furthermore, we posted corresponding articles on our own Facebook page and shared them in Facebook groups of relevant departments of colleges and universities nationwide. We placed ads on Facebook and tried to reach out to students via student council mailing lists.

Teachers and students were invited to participate in two phases from January to March and from May to July in 2019: After the online teaching unit, students were able to take on a self-selected number of research tasks for the duration of two weeks, i.e., they collected information for our data set and gathered points for the competition. Teachers from twelve German universities found interest in our project, most of them agreed to announce our project in their courses for students to participate if they are interested (as add-on), one of them integrated the project directly into their course syllabus (as a 'plug-in' online teaching unit that can flexibly be integrated into a classroom course on social science methodology). For many teachers, the integration into the course (as plug-in) was not possible due to bureaucratic challenges and time constraints. During the first phase, a total of 44 students registered; twelve of whom completed the online teaching unit, including the test. Eventually, six out of this group took on research tasks. Due to the lack of competition, all participants in the first round received one of the prizes from the competition. In the second phase, 52 people registered to participate, 39 of whom researched tasks, of which we distributed prizes to ten people with the most research points. Within four weeks, 96 students participated in the online training. A total of 300 cases (out of 1,500 available cases) of entrepreneurial groups were researched.

2.3 The Connection of Online-learning and Crowd Science

Conceptually, our approach of Crowd Science infused Learning combines a research component (crowd science) and a learning component (online teaching). In both components, we made key decisions that ultimately manifested themselves in our platform's design. Figure 1 summarizes the course of our conceptual decisions, which we will discuss individually below.

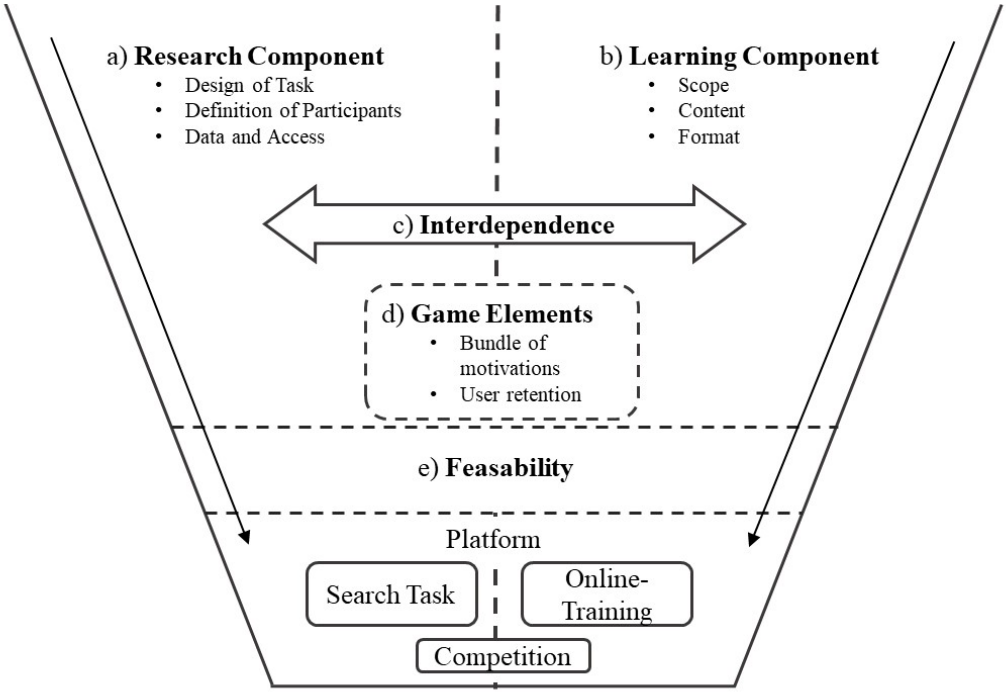

Figure 1: Decision-making moments in the combination of crowd science and online teaching

(a) Research component

Regarding the research component, we defined the nature of the task as a research task, including the types and accessibility of data used, and have specified the potential participants for our project (Scheliga et al., 2018). Our research aim was to identify typical development paths and central transition moments in entrepreneurial groups (Ruef, 2010; Stamm et al., 2019). Within the scope of our research, we aimed to build up a longitudinal data set based on commercial registry data, which allows us to identify such entrepreneurial groups at the time of new registration and track changes within the group (Weinhardt & Stamm, 2019). However, the commercial register data itself contains only limited information on the group members' social relations. A crowd science approach was used in order to supplement this information.

Specifically, we designed the task so that participants should research information about the group members' social relations at the time of founding (e.g., relatives, friends) in various publicly accessible sources. It was also important for our research that participants document the research process to be able to check the data later. They should record the link of the found source and corresponding text passages in a result form.

We selected sociology and management (entrepreneurship) students as potential participants in this task. Strategically, we did not attempt to build a new community but rather mobilized what we believed to be an existing professional community (Scheliga et al., 2018). For the task's design, we focused especially on achieving a fit between our research interests and our target community's interests. We increasingly simplified the task throughout our extensive pilot and test phases and limited the sources to be used down to two: company websites and newspaper articles. We provided access to a digital newspaper archive to carry out the research. The time required per case ranged from a few minutes to one or two hours, depending on the amount of information found.

b) Learning component

We defined the topic, scope, and format of the online teaching unit for the learning component. Regarding the topic, we focus on a social science data lore of process-produced data (Baur, 2009; Bick, 1984), defining and discussing this form of data and their relevance for social science research. We developed the online teaching units content based on the current state of research and discussions with colleagues specialized on this topic at various universities, refining it several times. The unit begins with an introduction to social science data and its principles, which are explained and exemplified based on three data types (websites, news articles, and registry data). Students gain insight into the variety of process-produced data and the data traces preserved in them. They are also familiarized with the evaluation of data sources and quality. Finally, we offered a reflection on the possible applications of such data.

To keep it concise, the scope of the online teaching unit should not exceed that of a single regular in-person classroom session. The result consists of seven self-produced educational videos with a total duration of 45 minutes. Most of these videos were designed as 'explanatory videos', i.e., a person is shown explaining a certain subject from the front, with terms and graphics displayed to support the explanation. An outside camera-shoot, interviews, and various image materials make the online teaching unit varied and attractive. The script for these videos is based on established design elements in online teaching (e.g., short sentences, rhetorical stylistic devices, repetitions, and summaries) (Kepser, 2010; Pearson, 2010).

The result was a 'plug-in' online teaching unit that can easily and flexibly be integrated into a classroom course on social science methodology and be offered either instead of a single session or in conjunction, thereby, creating a blended learning situation (Auster, 2015; Luna & Winters, 2017). The format enabled students to gain direct access to up-to-date research knowledge in the field of process-produced data and is useful for teachers and students as a contemporary and relevant supplement to methodological training. Typically, reactive methods (qualitative interviews, survey methods) take up a large part of the already very extensive curriculum. A critical examination of process-produced data seemed a much-needed supplement when we started our project. Our unit thereby offered a useful addition to the existing curriculum of social science methodology regularly taught at universities.

c) Interdependence of the components

Combining a research and learning component (as described above) makes it necessary to reflect that every decision made concerning one component might impact the other component and vice versa. For example, the decisions made on selecting learning content were linked to qualifying the participating students for the subsequent research task. Thus, in the online teaching unit, we only present those data types that we use within our research (i.e., register data, websites, and newspaper articles). Conversely, the formulated task should serve our research-strategic goals and allow students to experience the internet as a research space, practically apply learned knowledge, and develop related competencies.

The challenge now was to design a research application that students could handle competently and reliably in terms of extent and complexity, which would train them in the handling of process-produced data and at the same time produce valuable information for us. The task we have chosen is relatively complex. The research required a high degree of independence, skill in dealing with the search platforms used and the respective sources, and the interpretative ability to evaluate statements. In principle, this provided a good basis for the learning processes, especially in contrast to the simple, repetitive tasks of narrow range that often dominate crowd science projects (Scheliga et al., 2018). A didactic added value could be achieved on at least three levels: First, regarding the use of process-produced data, which in our case were used as sources; second, regarding content issues such as business start-ups and group processes; and third, regarding a part of the social science research process.

(d) Game elements as additional incentives

Our considerations revolved around what we thought the students could and should be expected to do, what incentives we could provide, and how

to motivate them (ideally) to participate continuously. As the literature on online teaching and crowd science (Franzoni & Sauermann, 2014) shows and problematizes, various motivational factors, some of which may be conflicting, must be assumed. Intrinsic motivations result from participants' pleasure of taking part in the required activity as such, including personal interest or enjoyment (Nov et al., 2011), the chance to learn more about a certain subject, and the fulfilment of discovery (Raddick et al., 2010). Extrinsic motivations are based on the desire for achievements or incentives external to the actual task, such as social recognition or financial rewards. Other sets of motivations have also been described in the literature. For example, volunteers exhibit altruistic motivations ranging from a general desire to help, a desire to contribute to science or the public good, and a desire to help one's community (C. Phillips et al., 2018; Raddick et al., 2010). These overlap with social motivations such as the desire to socialize, interact with others, and to be recognized as part of a community (Bowser et al., 2013; Nov et al., 2011). Especially for designing crowd-science projects, it is also important to recognize that the initial motivations for taking part in a project may differ from those motivations for continued engagement in a project (Rotman et al., 2012, Tinati et al., 2016).

In our considerations, we realized that our possibilities to utilize typical extrinsic incentives expected in a university teaching context (such as credit) are limited. We thus decided to emphasize play as a way to increase participant motivation and engagement (Rejane Spitz et al., 2018). In addition to the promise of learning something and contributing to research, we set out to create additional extrinsic incentives through game elements (Deterding et al., 2011, p. 10). This idea was supported by the fact that game elements had already been used and researched frequently and successfully in other prominent crowd science contexts (Koivisto & Hamari, 2019). Gamification is viewed as a powerful design technique that has the ability to improve user experience and transform mundane, repetitive tasks into engaging experiences (Franzoni & Sauermann, 2014), thereby motivating and retaining participants (Bowser et al., 2013; Bowser et al., 2014; Iacovides et al., 2013; Pedersen et al., 2017). Such game elements include for example rewards, online gaming badges, leaderboards, or competitions (Simperl et al., 2018). Gamification may encourage people to take part in a project or help to sustain engagement, or both (Rotman et al., 2012; Simperl et al., 2018). Similarly, communication tools and community elements may help to sustain engagement over time, by allowing participants to interact through recognizing their achievements as meaningful (Iacovides et al., 2013; Tinati et al., 2016). At the same time, gamification in citizen science has been met with criticism and even warnings against its usage (Graber & Graber, 2013). Games and science, for example, may be viewed as independent and even contradictory activities

(Ponti et al., 2015). The design of gamification elements in crowd science must balance the demand for participant engagement and enjoyment with scientific relevance and methodological rigor (Ponti et al., 2015).

In the design of our Data Traces project, we acknowledged gamification is most effective when it is used to stimulate real, intrinsic motivations (Deterding, 2012). Hence, elements and extrinsic rewards such as points and badges may be used as way to support intrinsic motivators to recognize thematic contributions and expertise (Iacovides et al., 2013). We thus linked the students intrinsic motivation to learn and to contribute to a scientific project to gamification elements. The result was a points system in a competition for individual players and groups, introducing additional financial incentives. Students received points for entries on the user interface (both from source references and data), which were displayed on the website besides a ranking of the best-placed students. For those participants who scored the most points within two weeks, we distributed substantial cash prizes of up to € 300 per individual. Thus we wanted to tie into the concept of 'idea competitions' known in economics (e.g., business plan competition, case study competition). With this technique, we hoped to address yet another possible motivational factor for students in order to increase their willingness to participate and create stamina to keep going (Deterding et al., 2011, p. 9).

(e) Feasibility

Not all conceptual ideas could be realized due to time, financial and technical restrictions. Furthermore, decisions made during the conception phase led to path dependencies, whereby some decisions turned out to be disadvantageous. Technical possibilities in particular proved to be limiting. For example, we would have liked to make the website more dynamic or use game elements that focused more on participation instead of implementing a purely points-based competition (e.g., by addressing participants directly as part of a virtual research community).[2]

3 THE CONNECTION OF THE COMPONENTS AT TEST

A central goal of the Data Traces Project was to develop and test the application of Crowd Science infused Learning. While the combination of crowd science or citizen science with teaching in a formular setting has been explored before settings (although not too often, for examples see Karlin & La Paz, 2015; Mitchell et al., 2017; C. Phillips et al., 2018), our project was unique in several ways. First, our project was situated in the social sciences

[2] Their critical reception within sociology and game studies we had taken note of (e.g. Fuchs et al. 2014).

rather than the natural sciences in which there is much more experience in this regard. Second, we developed a 'plug-in' format that could be used not just in the context of our institute, but also by other teachers at other universities. This potentially allows for a greater usage of the teaching materials we developed as well as a greater reach of participants to achieve a critical mass of research volunteers (in this case, students). Third, in line with other crowd science projects, we used points and a leaderboard as gamification elements in our project, but we also ran a competition and offered monetary prices. This kind of prize competition is a setting in which seemingly no previous experience has been obtained so far.

A central goal of the Data Traces Project was to develop and test the application of Crowd Science infused Learning. Therefore, a reflection and evaluation on our project must specifically address the connection between crowd science and online teaching. It seems to be of central importance to reflect on the form and context of participation which such a concept generates and demands. During the Data Traces Project, we implemented multiple reflection sessions within the research team, received evaluations from two seminars, conducted two focus groups and four semi-structured interviews with participating students. We further collected emails and comments we received on social media by students, teachers, and multipliers. The protocols, interview transcripts, evaluations and other documents serve as basis for the following reflections.

3.1 Participation in the research process

While the aspect of contributing to research is present within the framework of our Crowd Science infused Learning project, it is limited at the same time, as the task is designed to be fulfilled within a very limited amount of time (a few minutes). Students could not participate in the research question's design, the selection of the theoretical framework, or the selection of cases. Instead, they were asked to research data on a specific issue, so their contribution may also have felt 'small'. Nevertheless, the research was perceived as productive and the given freedom in the task was evaluated positively. Finding information was described as a positive experience: first, because a certain fulfillment could be found in searching as such, and secondly, because it is 'nevertheless, of course, also a contribution to research' (Interview 1: 27). However, the research task we set also entailed the risk of not finding any information about a given case and thus not coming to any tangible result. If this was the case, some students had doubts about whether their procedure was correct. Others perceived the difficulty and personal improvement in finding data as part of the learning process on the types of data used as well as their respective limitations.

As in other crowd-science projects based on voluntary participation, fun and fulfillment play a key role (Raddick et al., 2010; Reed et al., 2013). The probability of participation increases if one succeeds in awakening interest in the topic and making the task tangible and feasible, for example, by pleasing satisfactory research tasks (Bonney et al., 2009; Franzoni & Sauermann, 2014). In our case it is therefore necessary to critically question whether we have chosen a suitable topic for the task at hand. In an interview, a student told us that it was *'kind of cool to find out about companies you don't know. You feel like a little spy (laughs slightly)'* (Interview 1: 27), yet the low participation rate could also be an expression of a lack of topical interest. In any case, it should be noted that not every topic is equally attractive, and not every task may seem equally pleasant.

Furthermore, the participation in our Crowd Science infused Learning application is guided by the teachers on-site, who are researchers themselves. In our approach, the teachers are mediators who assess the research's seriousness and quality, such as how well the topic suits their students' interests. Teachers may even compete with the providers if research interest's overlap, or students are recruited to work on their own research. This adds a whole new level to the design of the project, which now not only needs to appeal to the volunteers doing the research work, but also the fellow university teachers who are envisaged to promote the project in their classes. Hence, their motivations and conditions of participation must also be taken into account. As this set-up is something new and previously untested, no experiences or recommendations existed as guidelines on how to approach this challenge.

Finally, students' participation in research is also subject to some restrictions for the researchers who offer the project themselves. In contrast to other formats of crowd science, we can rely on a minimum of previous knowledge, but due to the complexity of the task, we must have confidence in the students' competence. An example of this is the extraction of the desired information from relevant text passages. This information first had to be identified in newspaper articles or websites and often required additional interpretation later on. We demanded a series of protocolization steps for the necessary quality assurance and methodological comparability. Even though these steps reduced the task's attractiveness, at the same time, they supported this research-relevant step didactically.

3.2 References to familiar teaching contexts

Within the framework of our Data Traces Project, we have created the possibility of a digital experience of inquiry-based learning. Ideally, our online teaching unit could easily and flexibly be integrated into a classroom course on social science methodology. As we offer a teaching plus research

unit that we ask teachers to integrate into an existing curriculum, we speak of a 'plug-in' format. While some projects have experimented with the idea of offering inquiry-based learning through participation in citizen science projects settings (Karlin & La Paz, 2015; Mitchell et al., 2017; Oberhauser & LeBuhn, 2012; C. Phillips et al., 2018; Ryan et al., 2018), our digital 'plug-in' format is a genuinely new idea that, to our knowledge, has not been realized before. The evaluation of our offer by students and teachers focused on the specificity of this learning experience in the digital space. One student explained in an interview:

> "I found the videos very good. They were also very instructive; I thought the example was quite good. And with the platform itself, with this participatory action, I found it quite cool how it was divided up with the easy, medium, and difficult tasks." (Interview 1: 37).

And one teacher wrote to us:

> "The feedback from the students was clearly very positive. [...] In general, this would be a great example of successful blended learning. Even though most of them had hardly had any contact with the topics so far, they found the approach very exciting and 'finally something new." (Teacher's e-mail).

The offer thus stands out above previously familiar forms of digital teaching.

However, this digital learning experience remains connected to the context of classroom teaching through its 'plug-in' format. As providers of this format, we intervened as unknown third parties in institutionalized interactions between students and teachers. We decided for a plug-in format strategically in order to approach a specific community and to be able to draw on the usual resources (namely, the structure of a course and the social capital of the teachers). However, we did not sufficiently consider the consequences of this intervention and, above all, the context of the participants; especially in sociology, a teaching and learning culture is widespread, which - with great justification - relies on the discursive exchange between students and teachers. Our offer of Crowd Science infused Learning gives teachers a completely different function. They do not propose the basis of discourse anymore; moreover, they are no longer intended as discursive participants. Instead, teachers are assigned a gatekeeper function: they must now assess the quality of the teaching content that others have selected and prepared, decide whether it meets their requirements and whether the content fits into the rest of the teaching program. As a consequence, teachers may view the demands of plugging Crowd Science infused Learning into their formal curriculum as an encroachment on their autonomy of course design.

In this constellation, we underestimated some central aspects: firstly, a relationship of trust is needed between the providers of Crowd Science infused Learning and the teachers on site. Thus, it is no coincidence we had collegial connections to all teachers who referred to our project in the first round, or with whom we had a personal exchange about the teaching curriculum contents and the research task. This is also true for the teachers who invited us to their classes or ultimately participated with their entire course. Secondly, we have considerably underestimated the fact that – at the time – online teaching was regarded with great skepticism. Possibly, teachers feared that an online-format undermined a discursive learning culture. The collective experience of online-teaching during pandemic circumstances certainly affects the willingness to try out online teaching formats. Thirdly, we underestimated the time and effort required to incorporate such a teaching format into the respective teaching curricula, which are relatively standardized, especially in terms of methods.

After all, students frequently asked us what they would gain from participating in our crowd science project. However, it was not our decision, but rather the teachers' decision on-site, whether our project became part of their course, including the awarding of course credit. We were only able to offer a relatively insignificant certificate for the successful completion of the online teaching unit. Due to the lack of accreditation of the online teaching unit, it was all the more necessary to convince the teachers as mediators.

This may point to an overall problem of using students in a standard university setting. Usually, with 'traditional' citizen science volunteers, the initial, intrinsic motivation to participate in a science project, such as an interest in the topic or science more generally, is replaced by the university teachers' request to take part. Hence, it is unsurprising that the question of benefits and rewards arises and probably needs to be addressed differently than in other projects. As initial intrinsic motivations could be lacking among the students (when they are told to participate as part of their university education), it seemed promising to offer other motivating factors, such as game elements in the form of points, leaderboards, prizes and competition in order to stimulate students' motivation (see discussion below).

Although we were aware of the problems and importance of addressing both students and teachers, we underestimated the effort involved and probably overestimated our ability in the art of communication. As university-integrated researchers and lecturers, it was obvious that we were able to anticipate the needs and interests of our colleagues and students relatively well. However, it became clear that the range of services offered by Crowd Science infused Learning, although in

itself a meaningful unit, must be more closely aligned to the teaching context.

3.3 Ambivalent effect of game elements

Our use of game elements in the form of a competition with prizes aimed to provide further incentives in addition to purely research-based learning and offer some compensation for the students' time. On the students' level, the effects proved to be quite positive. For instance, several students described how the combination of points and competition motivated them to participate longer without completely overshadowing their interest in the research activity. One student reported:

> "I would say my goal, in the beginning, was simply to participate. Or just to see what's there [...]. The goal, somehow in the middle of the action was, yes, I just want to have more points [...], in the end, it was a little bit like this [...] maybe if I spend another half an hour there is something else I haven't seen before?" (Interview 2: 18).

In this respect, our calculation to give the students feedback on their performance through points and keep them in the competition for a longer time worked out very well. It was particularly evident in the students' final sprint during the second phase. This finding is in line with previous research indicating that initial participation is largely driven by the desire to learn and participate in scientific research, but that sustained engagement may be supported by game elements (Simperl et al., 2018).

However, the game elements, especially the financial incentives, were viewed rather critically by some local teachers and multipliers (student councils, magazines), even though they were complementary and optional. This quickly led to an implicit or explicit rejection of our project as a whole. For example, our e-mail inquiry to a sociology student journal asking whether we could publish a call in their journal was rejected because it was seen as 'neoliberal' with critical reference to the competition's financial incentives. Particularly because financial incentives to participate in surveys or idea competitions are well established in other subjects, it is obvious that the explanation for these reactions can be seen in the role of sociology as a science reflecting about the social conditions of production. The sociological debate on the subject of gamification has so far focused almost exclusively on it as an instrument of control (e.g., Rey, 2014; Whitson, 2014). While we tried something new with our offer, at its core, it was based on the expectations of inquiry-based learning. However, the critical perception of our (purely optional) competition dominated, especially within the group of gatekeepers in the field. In summary, the game elements' specific design had ambivalent effects on the perception of

and participation in our project. While the game elements were viewed critically by some colleagues and gatekeepers, they helped motivate students to participate and engage in the research task without completely overshadowing the research and learning incentives. This in line with parts of the literature on gamification in citizen science where some argue for the benefits of gamification, while others emphasize the dangers involved. For example, intrinsic motivation might be replaced by extrinsic motives (Deci et al., 1999; C. Phillips et al., 2018), which may boost participation in the short term but could prove detrimental to engagement and the scientific cause overall in the long term. Our project was designed to offer a range of features with different attributes in order to appeal to different audiences with varying interests and motivations (after all, we wanted to attract students from sociology as well as entrepreneurship classes). However, it is possible that some of these features overshadowed others, reducing the overall appeal of the project to participants. In our case, for example, it could be that some students interested in the science behind our project may not have participated as they may have been put off by the competition element. Thus, while appealing to different user groups through different design elements still seems to be a good strategy to maximize participation, project managers must be careful how these are communicated and presented to audiences so that each audience is attracted by those features which are tailored towards them.

4 OPPORTUNITIES, CONDITIONS, OUTLOOK

In our Data Traces Project, we used large human and personal resources to test the connection between online teaching and crowd science. Despite technical challenges, criticism from the field and the fact that the number of participants was ultimately low, we consider the idea to be principally viable. We would like to motivate people to continue experimenting with this format. From our perspective, Crowd Science infused Learning holds at least three interesting opportunities.

Firstly, the format allows integrating a new variant of inquiry-based learning to established teaching formats such as seminars or lectures, even beyond specified methods courses or student research projects. In this way, the teaching experience - described as predominantly positive - can be extended to gain practical insights into partial steps of the research process. Secondly, the online teaching unit gives students access to expert knowledge and provides the opportunity for repeated consumption of the teaching unit. Teachers on-site can use this format flexibly. Thirdly, Crowd Science infused Learning allows to formulate relatively demanding tasks and access data types that are otherwise difficult to access or to interpret relatively complex data. In this respect, according to our own experience

and critical analysis, Crowd Science infused Learning holds considerable opportunities for research and teaching in the social sciences.

Simultaneously, the critical-analytical view of the connection between online teaching and crowd science has shown how many preconditions must be met before it can become successful. To sum up, we can formulate three conditions under which Crowd Science infused Learning can be sustainable: (1) an establishment of a culture of mediation, (2) a fit with the local teaching context, and (3) the formulation of a task that takes learning and research effects equally into consideration.

(1) Crowd Science infused Learning, as proposed here, is integrated as a sub-element in an existing course. Thus, it requires the willingness of local teachers to take on a mediating role. Therefore, it is important not only to acquire an interest in this format among teachers of sociology (or other disciplines) but also to convince them of the quality of the content and the benefits for their students. Only if courses are large enough or a critical mass of teachers agrees to implement this format into their teaching, participation can be scaled. This would then justify the effort to produce the online teaching unit and its platform and generate a sufficient number of tasks to be worked on for research. Such a culture of mediation cannot be realized within a few months but requires a considerable amount of time. However, likely, this community of experts would also be easier to mobilize to work on other tasks. This, in turn, argues in favor of anchoring Crowd Science infused Learning in a permanent digital infrastructure, which could then be filled with interchangeable content.

(2) In our reflection, it also became clear that Crowd Science infused Learning needs to fit in with the teaching context on site. On the one hand, this concerns integrating this format into existing curricula. A moderated exchange on the respective teaching content with the teachers on-site seems necessary first. On the other hand, the learning performance for the respective course should be credited, at least partially. Without this official recognition, Crowd Science infused Learning remains a purely voluntary activity, which does not necessarily justify the focus on students as the crowd. In this respect, creating the ability to fit in with the respective teaching context also means addressing and applying existing incentive structures.[3]

(3) A task must be developed that allows the knowledge from the teaching unit to be applied in research and considers the learning effect of the students as well as the interests of the offering researchers equally. Assignments of medium complexity such as data research (as in our

[3] Accordingly, we would argue from our experience that other incentives, such as those that can be generated by game elements, should only be used cautiously.

example), the interpretation of texts, or the recording of short audio or video sequences are conceivable.

The complexity of these conditions shows that Crowd Science infused Learning's possibilities are not easily realized. Nonetheless, we can imagine at least one scenario in which an adapted concept could be implemented. In this scenario, an association of lecturers at universities within sociology and the social sciences jointly commit themselves to Crowd Science infused Learning's further development. They exchange information about the online teaching unit's quality standards, use synergy effects in the production of the online teaching unit and the construction of the platform, and agree to regularly incorporate the format of digital inquiry-based learning into their classroom courses. The task following the online teaching unit could then be exchanged over time. Within such a circle, a culture of mediation could be established. The ability to fit into the teaching context could be set up, and changing tasks could be formulated that take the teaching and research interests of participants equally into account.

Such a culture of mediation would mostly encompass social scientist and researchers working together to achieve the common goal of establishing the desired research and teaching platform. Together, they might form a more or less institutionalized network to keep the platform up and running by sharing and collaborating on research tasks, teaching content and the recruitment of students and volunteers. This is somewhat different from collectives and communities of citizen science volunteers that have developed in some of the existing, long-standing citizen science projects based on the possibilities of participants to communicate and cooperate with each other as they perform the requested research tasks (Tinati et al., 2016). Such volunteer communities can foster the research process as volunteers help each other through the exchange of tips and tricks on the research tasks, but also through developing gamification elements of their own, setting up their own research puzzles objectives which are shared and recognized by other members of the community (Greenhill et al., 2014). However, these two communities, researchers and volunteers could very much overlap and benefit from each other. Through ongoing engagement, volunteers could develop a say in the design of research tasks and teaching units. For volunteers, on the one hand, this could mean a role change from "merely" contributing to fully cooperating or even co-creating citizen science projects in conjunction with researchers. Researchers and scientists, on the other hand, could benefit from such a devoted pool of research volunteers and participants as recruiting new participants for a newly established citizen science project always is a challenge.

Finally, we like to note that the current teaching environment needed to be radically adapted during the COVID 19 pandemic (Gillis & Krull,

2020). The integration of Crowd Science infused Learning as an online teaching unit and a digital form of inquiry-based learning seems less challenging when integrated into online learning environments than when we tried to integrate it into analog classroom settings. While it is still too early to see what the long-term effects on the collective experience of sociology teachers and students in terms of learning will be, Crowd Science infused Learning certainly offers online courses on sociological methods or other sociological sub-disciplines (in our case, organizational or economic sociology) to link research and teaching in an innovative manner.

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