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Immersive simulation and experimental design in risk and crisis management: Implications for learning

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Abstract

Experiments have long been recognized as effective tools in teaching natural sciences and, to a lesser degree, in social sciences. However, understanding the role of immersive simulation experiments in undergraduate degree programmes demands more scholarly attention, given the pace of technological advances and research literacy in immersive simulation. The purpose of this article is to illustrate the potential of integrating immersive simulation laboratory experiments in social science education and specifically in a risk and crisis management undergraduate degree programme. Based on the work of Claire Dunlop, we demonstrate how an experiment with a high degree of experimental realism was a fruitful vehicle for initiating conversations about sensitive subjects in a safe environment and made teaching more inclusive, while high mundane realism made teaching risk and crisis management fun, and, we argue, fostered practical aspects of risk and crisis management.

KEYWORDS
experimental design, immersive simulation, poisson regression

1 | INTRODUCTION

Simulation, the running of a model with appropriate inputs for the purpose of observing the outputs (Axelrod, 1997; Bratley et al., 1987), has become a recurrent feature of research in the natural sciences but is also used to a degree in social sciences as it can contribute to the understanding of complex social processes (Gilbert, 2004; Sawyer, 2003). Computational simulations involve modelling and computer-aided simulation techniques (Gilbert & Troitzsch, 2005), while immersive simulations may range from narrative fiction and film (Mar & Oatley, 2008), to low-technology representations of real-life situations (see e.g., Scott & Pandey, 2005) at one end of the spectrum, and at the other end, high-technology immersive simulations spaces (e.g., IMTEL, 2019; MIUN, 2019). Concomitantly, simulation seeps into everyday life in entertainment, applications, and gaming, in education and training, and in various 360° VR applications such as visualization in the manufacturing and construction industries, in product demonstration and the buying and selling of real estate, just to mention a few. More opaque, however, are the potential utility and the challenges immersive simulation techniques pose on teaching and learning, particularly in the social sciences and specifically in degree programmes with a distinct applied focus (Sparf et al., 2019).

The aim of this paper was to shed light on simulation-based laboratory experiments in teaching in the social sciences. More specifically, the following research question guided our research: *what kind of utility do simulation-based laboratory experiments have within the risk and crisis management education field?* To tackle this question, we drew from the seven reflective dimensions promoted by experiments as outlined by Dunlop (2022), originally for the teaching of public administration. Reflexive dimensions, according to Dunlop (2022), comprise the space for reflection in teaching; they are ways to promote critical, reflexive thinking among students so that they may hone the skills needed by practitioners, be it in the public or private sectors. These include *initiating conversations about sensitive subjects; making [risk and crisis management] teaching more inclusive; de-mystifying concepts; improving communication skills; improving research literacy; putting professional baggage in its place, and making [risk and crisis management]*[1] *fun*. We leveraged all these dimensions against our overarching research question and found that three of them were relevant for the experiment under examination in this study: *initiating conversations about sensitive subjects, making [risk and crisis management] teaching more inclusive*, and *making [risk and crisis management] fun*. The qualitative data suggested an additional reflective dimension, *fostering practical risk and crisis management aspects*. Additionally, we show how experimental realism (how realistic the experiment scenario is) and mundane realism (how realistic an experiment environment is) underpinned this set of four reflective dimensions in teaching (and learning) risk and crisis management.

As Dunlop (2022) notes, the popularity of experiments as learning tools in social sciences has increased recently but their pedagogical rationale is really an extension of student-centred experiential learning (Kolb, 1984). Following this line of thought, we explored the potential of integrating laboratory experiments in education as part of an undergraduate degree programme in risk and crisis management. The experiment was set up as a means of encouraging students to think about potential risks from a pluralistic perspective, which is an important skill for practitioners. We worked with two sources of data: we quantitatively analysed the data from the actual experiment, which we complemented with a qualitative analysis of the interviews with the research participants, all of whom were students of this programme.

The remainder of this article is structured as follows: after elaborating on the theoretical aspects of simulation as a concept and laboratory experiments in teaching within social sciences, we outline the laboratory experiment which formed the basis for this research. We then present the quantitative and qualitative results, which we discuss in the final section, together with some concluding remarks.

2 | SIMULATION AS A CONCEPT

The past few decades have brought on significant technological advances, which on the one hand, have revolutionized the way we understand the world and conduct research, and on the other, have created a new series of challenges. One such advance is simulation. The term draws from the Latin *simulare*, to make like (Skeat, 1993), whereas its Greek synonym *mimesis* [*μίμησις*] goes even further: representation as a means of art (Liddell & Scott, 1889). Simulation, in its ability to make like, to artfully represent (that which exists out there), blurs the lines between ontology and epistemology: the way we understand reality is part of that reality. Rapp (1982) notes that mimesis is not a mere imitation of nature but something in competition with it. It is the transference of certain materials into *another* medium, subjecting them to the channels and codes of that medium (p. 68, emphasis in the original). Writing in the field of gaming, Bowman and Standiford (2015) posit that a salient component of role-playing games is '*immersion into environment*' where meanings transfer from the ordinary to the extraordinary in alternate game space—as opposed to a process in which these meanings are merely copied from reality to simulated reality.

Simulations are used in teaching various disciplines because they facilitate the (re)creation of different scenarios that have the potential to engage students in actively making decisions after considering the viability of possible alternatives. In health sciences, simulations are used as an interactive technique to replace 'real' experiences with immersive, controlled ones (Gaba, 2004). The immersive character of simulations implies an interaction where the participant is activated so that they react to cues and stimuli. In the social sciences, simulations fall under two categories: computational and immersive simulations. In the artificial worlds created by computational simulations, models are multiagent systems consisting of autonomous agents working in parallel, communicating with and learning from each other (Edmonds et al., 2007; Morecroft, 2007). As agents at the micro level interact, patterns emerge at the macro level (Sawyer, 2003). Such interactions are often nonlinear and complex; constructing computer programmes that can simulate human behaviour has the potential to facilitate the understanding of complex social processes (Gilbert, 2004; Gilbert & Doran, 2018). Such simulations are used for prediction, performance, training, entertainment, education, proof, and discovery (Axelrod, 1997). Whitehouse et al. (2012) posit that a simulation is a theory in itself as well as a special methodology. This is because, for a theory to be simulated, it must be developed and specified to such a degree that it may be demonstrated on a computer. In other words, the process of building a simulation leads to theory refinement and we posit this is the case even when it comes to building an immersive simulation.

In practical terms, immersive simulation offers some advantages over more traditional exercises in the field of risk and crisis management. Conducting an immersive simulation exercise offers a safe environment where participants may not only make mistakes but also learn from them while avoiding negative consequences, as Berndt et al. (2018) point out when it comes to virtual reality (VR) based simulations of mass casualty events (see also Mantovani & Castelnuovo, 2003). For example, a VR-based simulation can provide a realistic experience of fire, explosions, or toxic gas without the danger to the participants that exposure to these risks would entail. Indeed, lack of realism is one drawback of traditional exercises (Conges et al., 2020), whereas simulation-based learning facilitates error mitigation and promotes a culture of safety, partly through fostering teamwork (Lateef, 2010). As early as 1997, Kleiboer noted that 'crisis simulations offer a close approximation of the stress and flow of events of a real-world crisis' (p. 200; see also Kleiboer, 1997;

J. A. Walker et al., 1989; W. E. Walker et al., 2011). Immersive simulations provide this approximation in a safe manner and once the simulation is set up, it is easily replicated. Additionally, earlier studies suggest that simulations provide a hands-on, practical aspect in education that students highly value. More specifically, Aertsen et al. (2013) found that students had learned more about the object of study (in their case, crisis communication) through the simulation of a crisis than they would have learned via more traditional, less practical methods. Conversely, Yusko and Goldstein (1997) leverage crisis simulation's didactic power in developing crisis leadership competences. Finally, the power of student enjoyment gleaned from simulations must not be ignored, as Coombs (2001) notes in a study integrating a mock crisis drill in a crisis management course.

An immersive simulation at its most abstract form is a narrative: a carefully constructed story that is an abstraction of the social world (Mar & Oatley, 2008). Mar and Oatley (2008) note that a simulation is akin to a narrative in two ways. First, those who consume a narrative experience emotions and reactions based on the events taking place in the narrative. Second, narratives represent and model the social world. To illustrate these points, immersive (theatrical) simulations used in political science education not only offer an abstraction of the political situation more easily comprehended by the students but also students reported a better learning experience because the simulation was engaging and enjoyable (Dacombe & Morrow, 2017).

The question of student (or research participant) engagement touches upon the issue of mundane versus experimental realism. A study exhibits high levels of mundane realism when the experimental setting closely resembles the way things look and take place in the 'real world'. Experimental realism, on the other hand, refers to whether the experimental situation is engaging enough to elicit responses from the participants and whether the participants experience what was intended by the design of the experimental situation (Kruglanski, 1975; Scott & Pandey, 2005). This debate is key to experimental design because of possible threats to internal and external validity. The artificiality of experiments has resulted in the criticism that results are not generalizable. However, the purpose of the experiment is not to produce generalizable results per se. As Berkowitz and Donnerstein (1982) argue, [l]aboratory experiments are mainly oriented toward testing some causal hypothesis and are not carried out to determine the probability that a certain event will occur in a particular population (p. 247). The emphasis is rather on whether the experiment captures the theoretical variables appropriately (Hoffman, 2020; Kruglanski, 1975).

Mook (1983) warns us against dismissing research only because it is artificial and differentiates between generality of empirical findings and generality of theoretical conclusions. Mook goes on to say that there are several reasons (beyond the generalization of findings) for which one might choose to conduct an experiment. Researchers may ask what is possible to happen under artificial conditions. They may want to show that something ought to happen in a lab environment. Conversely, they may want to underline the salience of something by demonstrating it can happen in the lab. Finally, researchers may seek to understand a process rather than generalize it to the 'real' world. Eastwick et al. (2013, p. 275) assert that there is 'nothing inherently invalid' about laboratory research that is 'cosmetically dissimilar from real life', while Vissers et al. (2001) posit that artificiality is not a binary concept and there exists no sharp distinction between field and laboratory settings. They take a relational approach to validity in the sense that evoking a response is not a quality of design but the result of the interplay of design and experimental subjects. When using experiments in teaching, experiments featuring relatively high experimental and mundane realism have the potential to engage the students to a larger extent and thus make the exercise more meaningful and more interactive.

3 | LABORATORY EXPERIMENTS, SOCIAL SCIENCES AND TEACHING

Even though experiments have constituted an established part of research in social sciences (Falk & Heckman, 2009) and their contribution to the development of formal theory has been recognized, experimental design instruction has not been part of the curriculum, which has resulted in researchers shying away from them (Martin & Sell, 1979; Webster & Sell, 2014). While there is not a true or perfect experiment (Morton & Williams, 2008), a study is an experiment—despite instances of informal use of the term in the past (Druckman et al., 2006)—only when a researcher controls the level of an independent variable (or in some designs, variables) before measuring the level of a dependent variable (Webster & Sell, 2014). Even in experiments that do not involve direct observation of subjects (e.g., some experimental designs in political science), researcher intervention characterizes experimental design, but it happens in the design stage before the data are measured (Morton & Williams, 2008). In other words, the deciding factor for experimental design is intervention: if the researcher observes without intervening, they are conducting nonexperimental research (Coleman, 2018). In a laboratory experiment, the subjects are recruited in the same location where the experiment takes place and the researcher controls almost all parts of the experiment except for the subject's behaviour (Morton & Williams, 2008).

The purpose of experiments is three-fold: First, a researcher may be searching for facts, aiming at isolating the cause of some observed irregularity. Such studies are often combined with observational research. Second, a researcher may want to test predictions; such studies feed back to theoretical literature. Third, experiments that are designed to closely resemble real environments have the potential to influence policymakers (Druckman et al., 2006; Roth, 1995). These different purposes differ in the degree of generalization they require—whereas theory-oriented experiments are more abstract and not designed to address behaviours observed outside the study, a more practically oriented experiment designed to inform the work of policymakers may require higher levels of generalizability.

Finally, and most importantly for this paper, experiments as a means of active and interactive learning have the potential to activate students and enrich learning compared to traditional teaching methods that include only lectures or reading. Dunlop (2022) has identified seven reflective dimensions promoted by experiments in teaching public administration and public policy. We use Dunlop's (2022) work as a springboard and adapt these dimensions to the teaching of risk and crisis management as opposed to the discipline taken up in Dunlop's work. These dimensions are

- initiating conversations about sensitive subjects;
- making (risk and crisis management) teaching more inclusive;
- de-mystifying concepts;
- improving communication skills;
- improving research literacy;
- putting professional baggage in its place, and
- making risk and crisis management fun for the students.

In the section that follows, we elaborate on these dimensions and what they constitute in relation to risk and crisis management education. More specifically, *initiating conversations* regarding the ethical implications of the allocation of scarce resources and debating the question of the provision of risk-and-crisis-management-for-whom is a necessary component of any educational programme. Concomitant to this first dimension is the dimension of *making risk and crisis management teaching (and learning) more inclusive*, both in form and substance. In other words, it is important to include all students in learning activities, even ones who might not be inclined to participate and share their opinions, while at the same time urging students to be thinking about risk and crisis management for all segments of the population. Additionally, experiments, by promoting active participation, have the potential not only to facilitate the *de-mystification and subsequent understanding of otherwise intractable concepts* but also to improve the communication skills of students through the justification of making a decision or a series of decisions. What is more, taking part in an experiment gives insights into a particular methodology to students, thus *promoting their research literacy*. When it comes to students who are mid-career practitioners, experiments have the potential to promote perspectives outside their professional norms and experiences, what Dunlop calls *putting professional baggage in its place*. Finally, experiments bring abstract concepts to life, and for this reason, they can make *teaching (and learning) risk and crisis management fun* for the students.

4 | METHOD: THE LAB ENVIRONMENT AND THE EXPERIMENT

The data for this study are drawn from an immersive simulation laboratory experiment which took place at the RCR Simulation Lab at Mid Sweden University. The RCR Simulation Lab is an immersive simulation environment which may be used to simulate different scenarios through the projection of film, still photography, and virtual environments in 360 degrees. The lab consists of a simulation CAVE (cave automatic virtual environment), a control room, a separate observation/debriefing/conference room, and a lounge space. The 8× 8 m simulation CAVE features 360-degree projection, three-dimensional surround sound, a vibrating floor, scent and smoke machines, a range of temperature settings from 17 to 27 degrees Celcius, infrared heating, and theatre lighting.

The experiment was conducted in 2018 in the context of the undergraduate degree programme in risk and crisis management (with sociology as the main discipline) at Mid Sweden University University[2]. Twenty-eight students agreed to participate and they were randomly assigned in pairs.[3] The 14 pairs were randomly allocated to control and treatment groups[4]. Groups were received sequentially over a period of 2 days at the lounge area of the lab, where they received practical information and had a chance to sign the informed consent. The research team then handed them high-visibility vests and lapel microphones as they presented them with the experiment scenario.

The participants were told that in their capacity as students of risk and crisis management, they were asked to act as consultants for the company that manages the airports in Sweden. Their task was to identify as many risks (obvious and potential) as possible. The students were instructed to articulate their thoughts regarding the risks they considered by speaking aloud to each other. The treatment group received an extra sentence as part of the scenario—the research team asked them to specifically *consider risks posed to different people, including people with disabilities, those who did not speak Swedish, children and the elderly*. Pairs then entered the lab, where the research team projected a manipulated 360-degree still image of the arrivals hall of the local airport. Manipulations included a cart blocking the emergency exit, abandoned bags on the floor, an important message to the public written only in Swedish, exposed electrical wires, and others, as we elaborate in the following section. The 3-min experiment was complemented with an airport soundscape of announcement sounds and the sound of rolling suitcases, as well as yellow tape and actual suitcases on the lab floor. A research team in the control room observed the students move around and talk in the lab space. All sessions were audiovisually recorded. All participants were individually interviewed by a member of the research team as part of the debriefing process immediately following the end of the experiment.

The experiment data consist of the number of risks identified by the students as well as the kind of risk they identified.[5] The author team coded the latter individually, followed by a meeting to reconcile any discrepancies in the coding. These data were supplemented by the interview data of the individual debriefing of the 28 participants. Taken together, both data sources comprise the material of an idiographic case study (Levy, 2008), aiming at illustrating and unpacking a phenomenon rather than explicitly producing generalizable theory, which would have been hampered by the low level of participants. The ambition of this study is to highlight the potential utility of simulation-based laboratory within the field of risk and crisis management education, exemplified by the case of the high-tech simulation lab at the RCR Simulation Lab of Mid Sweden University. Further research in different educational and laboratory contexts may further the findings of this study.

In the section that follows, we present the quantitative and qualitative results.

5 | RESULTS AND ANALYSIS

The quantitative and qualitative aspects of this study are complementary. The quantitative data and analysis explore the experiment itself, that is, the behaviour of the control and treatment groups while the experiment was underway. The qualitative data and analysis pick up where the experiment ends, providing space for the students to reflect on their experience and the significance of this experience for their education in the risk and crisis management field.

5.1 | Quantitative data: The experiment

The quantitative data consisted of the following variables: first, each pair of students participating in the study was assigned a simple number (variable: *pair number*). Second, the variable *type of pre-test narrative* was randomly assigned to the control and treatment groups. As mentioned in the previous section, the control group was instructed to look for risks in the projected environment without any additional information, while the treatment group was nudged to look for risks relating to social inclusion with an emphasis on language competence and disability status. Third, researchers observing the experiments in the control room of the laboratory logged the number of risks (resulting in discrete numbers) that participants identified based on initial coding in real time—variable: *number of risks*. Additionally, the variable *risk type* was constructed based on coding by the author team. The conditions for this process are specified below:

	Count		
General risk	105		
Risk related to social inclusion	15	*Language*	6
		Disability status	9

To qualify for the category of *risk related to social inclusion*, the risk mentioned had to be connected explicitly to language competence and/or disability status, which the author team constructed as code sub-categories.

Risks related to language included the signage, which was in some cases only in Swedish and in text only. Mentioned risks related to disability status included tripping hazards dangerous for those with limited sight as well as revolving doors difficult for a wheelchair to go through. All risks not suited for the previous categories/sub-categories were sorted under the general category of general risk.

After the initial coding round, where each of the four researchers assigned categories according to the previously mentioned instructions, the categorization coincided at a rate of 97.5%. After further clarification regarding the non-conforming cases, we reached full consensus. The variable number of risks mentioned was normally distributed and hence suitable for mean-based parametric tests (K-S: 0.129, $p = 0.200$). Its unit of measurement is based on discrete frequencies rather than continuous measures, hence making it more suitable to rely on poisson-regression or similar generalized models (see Coxe et al., 2009). The variable is consistent enough with the poisson-distribution to make this suitable (K-S: 0.512, $p = 0.956$).

The variable of risk related to social inclusion is associated with similar conditions in relation to the distribution mentioned above (K-S: 0.142, p = 1.000), which is also true for the subcategory of disability status (K-S: 0.102, p = 1.000). Additionally, none of these three variables may violate the basic assumptions of the method. Having already assessed coherence with distribution, the other necessary item to evaluate was the independence of the counts between units of analysis (Lovett & Flowerdew, 1989). In this case, there was little reason to believe that the pairs subject to analysis would influence each other in such a way that this assumption would be violated. The subcategory of language had no count above 1 and can hence be handled as a dichotomous variable in statistical terms. However, since theoretically, it had the possibility of further counts, we included it in the poisson modelling.

In Table 1, we present three models of Poisson regression. For deviance, the models indicate some under-dispersion for social inclusion and disability status, while language is associated with severe under-dispersion. The omnibus tests indicate a good model of fit for social inclusion through comparison with one such only containing the intercept. However, language and disability status seem associated with a less good model of fit in each case. Thus, the only model appropriate for further analysis is the one related to the overall category of social inclusion.

In this model, the parameter estimates show a Exp(B) value of 3.333. With the control group set as a reference point, this indicates that the treatment group were 233.3% more likely to observe risks related to social inclusion. However, the model effect is associated with a p-value of 0.086, indicating that the current data is not sufficient to draw such a conclusion. In other words, the difference between control and treatment groups when it came to the identification of risks relating to social inclusion was not statistically significant.

5.2 | Qualitative data: The interviews

In addition to the data collected during the experiment, the research team interviewed all student research participants immediately after the completion of the experiment individually as part of a post-experiment debrief and second point of data collection. The interviews were semi-structured, aimed at capturing the students' experience during the experiment. We started by posing the

TABLE 1 Results of Poisson regression, three separate models.

Risks related to social inclusion				
Deviance	*Value*	*df*		*Value/df*
	10.087	12		0.841
Omnibus test	*Likelihood ratio* χ^2	*df*		*p-Value*
	3.977	1		0.046
Model effects	*Source*	*Wald* χ^2	*df*	*p Value*
	Intercept	0.555	1	0.456
	Group	3.345	1	0.067
Parameter estimate	*Exp(B) (95% CI)*			
	3.333 (0.917–12.112)			
Risks related to language				
Goodness of fit (deviance)	*Value*	*df*		*Value/df*
	7.257	12		0.605
Omnibus test	*Likelihood ratio* χ^2	*df*		*p Value*
	2.911	1		0.088
Model effects	*Source*	*Wald* χ^2	*df*	*p Value*
	Intercept	4.341	1	0.037
	Group	2.159	1	0.142
Parameter estimate	*Exp(B) (95% CI)*			
	5.000 (0.584–42.797)			
Risks related to disability status				
Goodness of fit (deviance)	*Value*	*df*		*Value/df*
	10.556	12		0.880
Omnibus test	*Likelihood ratio* χ^2	*df*		*p Value*
	2.942	1		0.086
Model effects	*Source*	*Wald* χ^2	*df*	*p Value*
	Intercept	2.441	1	0.118
	Group	2.441	1	0.118
Parameter estimate	*Exp(B) (95% CI)*			
	3.500 (0.727–16.848)			

Note: Predictor in each case: Group (test/control).

question, 'what did [the experiment] feel like?'. Students reported losing track of time and having the overwhelming feeling that they were at the actual airport. As one student put it: 'Personally, I completely forgot about time …it was so realistic, it was kind of like, I knew we were at the airport for a study visit… my brain just went "you've got all day"' (S4). Indeed, students reported experiencing the event as realistic even before entering the simulation room. The act of being handed a high-visibility vest and the set of instructions for the task at hand was an effecting transition to the reality of the simulation that followed. The combination of simulation elements contributed to the 'as if being there' feeling. As two students put it: [i] t felt really odd when the sound stopped, I was like, oh, what is happening now, you could notice that something cut in the environment right when [the sound] disappeared, the sound contributed a lot, and it was the combination of everything, all four elements building up the illusion, the stuff you had on, the tape [on the floor], the suitcases, the 360 projection, plus the sound, it was really seamless' (S12); 'it was a new experience, it felt a bit exciting stepping into an environment by walking through a door and ending up in a new place' (S9).

This seamlessness characterizing the structure of the experiment facilitated the pedagogical aspects of its purpose. Students pointed out the fact that the experiment highlighted the practical aspects of risk and crisis management in ways that the abstract reading of literature could not accomplish. They overwhelmingly expressed their enthusiasm over getting to test something new, to try something 'for real' and hands-on and to think about risks from the perspective of others rather than being 'stuck' in their own way of thinking. The experiment was described as a way to diversify learning activities, something really practical in terms of searching for risks '[…] and should be incorporated into the degree programme' (S18).

6 | DISCUSSION

The quantitative analysis of the experiment showed that even though the treatment group was more likely to identify a broader spectrum of risks, the difference was not statistically significant, meaning that the cause of this difference might have been due to chance. Therefore, we could not conclude that the difference in the narratives with which we presented the students made a difference in the number of risks they identified.

Having said this, the debriefing interviews following the experiment, conducted individually with each student participating in the experiment, suggested an added value of the activity as part of teaching crisis management at the undergraduate level. The experiment was a fruitful vehicle for *initiating conversations about sensitive subjects* in a safe environment. As part of their tasks, students discussed how the manipulations placed by the research team at the simulated arrivals hall would be seen by people with varied levels of functionality or limited language skills. This is especially relevant for students of risk and crisis management, who, in the future, they will have to make decisions about allocating scares resources to different population groups. Often underprivileged or underrepresented groups find themselves on the losing side of the redistribution of resources and attention. Experiments may reveal values and biases (Dunlop, 2022) that are consequential for the education of future risk and crisis managers.

The experiment in this study was designed to promote thinking about and potentially identifying risks from the perspective of others. Because it was based on immersive simulation technology, the experience was realistic without exposing the students to any kind of harm. What is more, the students were divided into groups of two so that they discuss what they saw and thought. Whereas the design of the narrative of the experiment aimed at fostering inclusion in substance, the group structure (dyads) fostered inclusion in form. It touched upon Dunlop's (2022) second dimension, namely, *making teaching more inclusive*. She notes that there exist students who tend not to participate in a classroom setting or in large groups, which results in their voices not being heard. The structure of this experiment, with a discussion in pairs and individual debriefings, ensured that all students had a chance to provide input and convey their thoughts to their colleagues and instructors.

These two reflective dimensions were underpinned by high levels of experimental realism. The narrative of the experiment was realistic enough to engage the students even before the actual experiment started. The students found the scenario credible and behaved as if they were consultants on a study visit tasked with identifying potential risks in an airport environment.

Conversely, the immersive simulation's high levels of mundane realism contributed to *making teaching risk and crisis management fun*. As Dunlop (2022) puts it (also supported by Coombs (2001), "the hands-on active learning of experiments fosters fun, excitement and playful challenge in the classroom" (n.p.), and this was certainly the sentiment conveyed by the students in the interviews. The hands-on, 'as-if-real' activity activated the students, who had fun while enriching their methodological and theoretical skills in what proved to be an entertaining way. Finally, the experiment *fostered practical aspects of risk and crisis management*; an argument echoed by Aertsen et al. (2013) and Yuskon and Goldstein (1997) when it comes to low-tech simulations in crisis management. This reflective dimension is related to Dunlop's *putting professional baggage in its place*, but for students who do not have baggage to start with. The students of this degree programme were generally relatively young, lacking practical experience. Being part of the activity translated abstract notions into practical actions, which was appreciated by all the participants. The students were able to hone practical skills in a safe (and realistic) environment, something that would have been more difficult to achieve in a classroom discussion without the immersive simulation creating the realistic backdrop.

That said, it has to be acknowledged that simulation-based laboratory experiments come with a not insignificant price tag. Such research infrastructure is expensive and not available in all universities, especially in lower-income countries. However, as mentioned elsewhere in this paper, simulations may be scaled up or down; what we have demonstrated here is that the use of a high-tech simulation experiment enhances students' reflexive learning in the dimensions elaborated above, encouraging more research in lower-tech simulation designs.

7 | CONCLUSIONS

This article aimed to explore the utility of immersive simulation laboratory experiments in undergraduate programmes in social sciences. As a means of reflecting on risk identification from the perspective of others, the experiment examined whether priming students with a more focused narrative would result in them considering risk identification from a broader perspective. Even though the experiment's results did not show a statistical significance of the consideration of risk between the control and treatment groups, the experiment, because it was high in experimental and mundane realism, was an effective teaching (and learning) tool. Based on high experimental realism, it initiated a conversation on a sensitive subject and it made teaching and learning more inclusive, whereas due to the high experimental realism of the immersive simulation, it made teaching and learning fun and it fostered practical aspects of risk and crisis management education in a safe environment.

Undoubtedly, the study had certain limitations, which delineate its scope conditions. In addition to the limited level of research participants, the experiment took place in a high-technology simulation lab, which is not a standard component of the infrastructure of all higher education institutions. However, as mentioned elsewhere in this paper, simulations have gradations and experiments featuring low-technology alternatives may potentially have similar results when it comes to the students' learning. There is currently also a rapid technological development of affordable hardware and software for VR and AR, which may open up for a broader use of simulations in educational settings, spurring new ideas for experimental designs. Concomitantly, the degree programme in this research featured inherent practical aspects. This is not to say that experiments may not be helpful in more theoretical degree programmes, even if to parse intractable theoretical concepts. Given the pace of technological advances, experiments based on a variety of degrees of simulation offer a promising learning tool for social science students.

AUTHOR CONTRIBUTIONS

All authors contributed jointly to this article and take joint responsibility for its contents.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

[1] The Dunlop text says 'public administration'. This is why 'risk and crisis management' here is in square brackets. Teaching public administration and risk and crisis management are not so different endeavours, as in

both instances, the degree programmes educate future public servants and consultants with (at least some) focus on policy. Having said that, it is beyond the scope of this paper to elaborate on this issue.

[2] See Supporting Information: Appendix A for images from the process.

[3] One student was a no-show on the day of the experiment, so the student who went individually was instructed to speak out loud for the microphone.

[4] In a case where the sample size is relatively small, which should be quite common in any test built around experimental design, the risk of low statistical power needs to be accounted for (see Cohen, 1992). Ideally, the sampling process is preceded by a power analysis appropriate for the method of choice. In this case, the data material was an already existing one, making such analysis practically impossible pre-sampling. Hence, the potential impact of using a small sample needs to be accounted for when interpreting the results. We took this into account in our analysis.

[5] There was no specific number of risks pre-defined by the researchers. Thus, no number of risks identified by the participants were right or wrong.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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