Krise i Syndstad: A Post Socio-Technical Incident Report on a Serious Game*

Thomas Richard McEvoy[1,†], Grethe Østby[1,*,†] Erjon Zoto[1,†,] and Stewart James Kowalski[1,†]

[1] *The Norwegian University of Science and Technology, Teknologiveien 22, 2819 Gjøvik, Norway*

Abstract

Serious games are increasingly used to teach socio-technical reasoning, yet there is limited empirical evidence on how students engage with complexity, contradiction, and organizational ambiguity during play. This paper reports on the first full deployment of *Krise i Syndstad*, a crisis investigation serious game previously introduced at STPIS 2025. The game simulates a multi-factor municipal flooding incident involving extreme weather, ICT disruptions, infrastructure degradation, and organizational misalignment. In this follow-up study, we present how Cyber Security students interacted with the scenario, how they conducted investigative interviews with 'municipal stakeholders' from the game-master-team, and how they attempted to synthesize competing scenario-injects under time pressure. Drawing on observational notes, learning artefacts, and pre /post-questionnaires, we analyzed the investigative strategies students adopted, the socio-technical factors they prioritized or overlooked, and the challenges they faced in constructing nonlinear explanations. In addition, we studied the game-master-team's learning experiences for possible change, that is, if the experience would lead to changes in the game in the terms of triple-loop-learning. The findings reveal persistent tendencies toward reductive causal narratives, difficulties integrating political and organizational constraints, and uneven use of the game's analytical tools. Moreover, we found indications that socio-technical inquiry and teaching moments in the game may lead to design refinements in the next iteration. The paper contributes empirical insight into how students learn, and struggle to learn, with systems-level reasoning through structured ambiguity and multi-actor simulation.

Keywords

Socio-technical systems, serious games, incident investigation, complexity and interdependence, tactical empathy, CDX, sensemaking, organizational dynamics

1. Introduction

Socio-technical failures rarely emerge from a single cause. Instead, they arise from interacting technical conditions, organizational routines, institutional constraints, and human sensemaking under pressure [1]. Yet students in information systems programs often approach complex

The 12th International Conference on Socio-Technical Perspectives in IS (STPIS'26), September 16–17, 2026, L'Aquila, Italy.

* Corresponding author.

† These authors contributed equally.

thomarm@ntnu.no (T. M. McEvoy); grethe.ostby@ntnu.no (G. Østby); erjon.zoto@ntnu.no (E. Zoto) stewart.kowalski@ntnu.no (S. J. Kowalski)

0000-0001-7322-4257 (T. M. McEvoy); 0000-0002-7541-6233-1234 (G. Østby); 0000-0001-9231-5437 (E. Zoto) 0000-0003-3601-8387 (S. J. Kowalski)

CC-BY logo & © 2026 Copyright for this paper by its author(s). Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR-WS.org/Vol-4334/paper9.pdf

CEUR Workshop Proceedings ceur-ws.org ISSN 1613-0073

published 2026-11-19

incidents with linear explanatory habits, including reductive reasoning, narrow technical framing, and difficulty integrating organizational and human factors. In the previously introduced STPIS paper in 2025 [2], Crisis in Syndstad (*Krise i Syndstad* - in Norwegian), a serious game designed to challenge these tendencies by immersing students in a multi-actor, multi-evidence crisis investigation was introduced. The game's design emphasized contradictory documentation, partial information, and the need to interrogate both technical and organizational narratives.

This paper reports on the first full deployment of the game with Cyber Security students (bachelor and master) in Gjøvik at The Norwegian University of Science and Technology (NTNU), Department of Information Security and Communication Technology. Whereas the original paper focused on the conceptual and design rationale, the present study examined how students actually engaged with the scenario, how they conducted interviews with 'municipal stakeholders', and how they attempted to synthesize competing accounts of a flooding incident complicated by ICT disruptions, infrastructure degradation, and organizational misalignment. The game required students to adopt either analytical (Team X) or relational (Team Y) inquiry strategies, mirroring investigative practices that combine evidence-driven questioning with tactical empathy.

Our aim in this follow-up study has been twofold. Firstly, we analyzed how students made sense of a deliberately ambiguous socio-technical situation: Which factors they prioritized, which contradictions they noticed or ignored, and how they attributed responsibility across technical, organizational, and political domains. Secondly, we reflected on the pedagogical implications of these behaviors from socio-technical inquiry teaching-moments in games, particularly in contexts where students must integrate technical expertise with organizational awareness. That is, we studied the game-master-team's participatory teaching experiences for learning development - if the experience would lead to changes in the game in the terms of triple-loop-learning.

Drawing on observational notes, student socio-technical learning artefacts, and pre and post-questionnaires, we identified persistent challenges in students' investigative reasoning, including a tendency toward reductive causal narratives and difficulty integrating organizational constraints into their explanations. We also highlight aspects of the game design that supported deeper systems-level reasoning, as well as areas requiring refinement. This paper contributes empirical insight into how students learn, and struggle to learn, with systems-level reasoning through structured ambiguity and multi-actor simulation.

After this introduction we present background and related theoretical foundations, before we present the method used to study the student's own adaptation of the game and the game-master-team's interpretation of the game and student's interaction. Thereby, we present the findings, before we conclude and suggest further development of the game more suited towards socio-technical learning adaptation.

2. Background

The initial STPIS paper (2025) argued that cybersecurity education often privileges technical reasoning and linear causal analysis, leaving students underprepared for the socio-technical ambiguity that characterizes real incident investigations [2]. The work identified three core gaps:

1. A tendency to treat incidents as technical puzzles rather than organizational events;
2. Limited attention to interpersonal dynamics, trust, and communication; and
3. A lack of pedagogical tools that expose students to contradictory evidence and politically shaped narratives.

The present study builds on those concerns, but shifts focus from design rationale to empirical evaluation: How students actually reasoned, interacted, and made sense of complexity when placed inside the simulation.
The initial STPIS paper [2] argued that cybersecurity investigations are shaped as much by organizational dynamics, interpersonal behavior, and emotional responses as by technical evidence. That work highlighted the limitations of purely analytical approaches and proposed *Krise i Syndstad* as a pedagogical intervention designed to expose students to ambiguity, conflicting narratives, and the human dimensions of post-incident inquiry. While the earlier paper focused on the conceptual rationale and design of the game, the present study is motivated by a different question: How do students actually learn when placed inside such a socio-technical simulation?
Cybersecurity education continues to rely heavily on logic-driven, procedural models of investigation. Even when framed as "socio-technical," many approaches remain analytically oriented, emphasizing systemic structures while underplaying the lived experience of stakeholders during crises. Yet real investigations unfold in environments marked by uncertainty, defensiveness, fear of blame, and incomplete information. These emotional and interpersonal dynamics shape what people disclose, how narratives are constructed, and which explanations become plausible. Understanding these dynamics is essential for developing investigators who can navigate complex incidents without defaulting to reductive causal stories.
Krise i Syndstad provides a controlled environment in which these dynamics can be observed. By analyzing how students interacted with stakeholders, prioritized evidence, and constructed explanations, this study seeks to understand not only what they learned, but how they learned it. The motivation is thus twofold: to evaluate the pedagogical effectiveness of the game, and to generate empirical insight into the cognitive and interpersonal challenges students face when investigating socio-technical incidents.

3. Theoretical foundations

Crisis negotiation literature suggests that empathy, relationship building, and active listening can unlock information that remains inaccessible through direct questioning alone [3]. However, these skills are rarely taught — and even more rarely assessed — in cybersecurity curricula.

3.1. From Technical Failure to Organizational Event

Socio-technical research treats organizational performance as emerging from the joint interaction of social and technical arrangements rather than from technology in isolation [4], [5]. The cybersecurity literature increasingly recognizes that incidents emerge from

interactions between technology, organizational routines, and human behavior [6], [7], [8]. Research on governance failures, informal workarounds, and incomplete feedback loops shows that incidents cannot be understood solely through technical analysis. The initial paper [2] positioned *Krise i Syndstad* as a pedagogical intervention that exposes students to these organizational layers. In this follow-up study, we examined whether students engaged with those layers or reverted to familiar technical narratives.

3.2. Communication, Trust, and the Human Side of Investigation

A second theme in the literature concerns the interpersonal dimension of incident response. Studies on trust, psychological safety, and emotional intelligence highlight how defensive behavior, fear of blame, and poor communication can obstruct investigations [9]. In addition, psychological safety, understood as a climate in which interpersonal risk taking is possible, supports learning behavior and information exchange [10]. Crisis negotiation research similarly emphasizes relationship building, calibrated questioning, and tactical empathy as mechanisms for eliciting information under pressure [3]. The Team X/Team Y inquiry model in *Krise i Syndstad* was designed to operate these insights. In this study, we analyze how students attempted to use these strategies in practice, and how their choices shaped the information they obtained.

3.3. Serious Games as Environments for Practicing Complexity

Serious games have become established tools for cybersecurity training, offering immersive environments where learners can rehearse decision making under uncertainty. Prior work shows that narrative immersion, role-based interaction, and scenario realism can support deeper understanding of socio-technical systems [6]. The initial paper proposed a game that foregrounds ambiguity, contradiction, and multi-actor interaction to contribute to this literature. The present study extends that contribution by providing empirical evidence on how students navigated these conditions, and where the design supported or constrained learning.
Recent reviews reinforce the growing role of serious games in cybersecurity education and training, particularly as environments for engagement and experiential learning. At the same time, the literature identifies a continuing need for stronger empirical evaluation, as many cybersecurity serious games remain at relatively early stages of testing and are evaluated with small participant groups [11], [12]. This makes the evaluation of how learners reason, interact, and respond to ambiguity during gameplay particularly relevant.

3.4. Sensemaking and Investigative Cognition

The central theoretical lens for this follow-up study is sensemaking. Weick describes sensemaking as an ongoing, social process in which people notice cues and construct plausible accounts under ambiguity [13]. Research in organizational studies shows that individuals construct meaning through narrative coherence, identity, and plausibility, especially when information is incomplete or contradictory [14]. Investigators often rely on simplified mental models and assumptions [15], default causal templates, or retrospective rationalization. These tendencies are highly relevant to cybersecurity education, where students may struggle to integrate technical, organizational, and political factors into a single explanatory frame.

By analyzing how students interpreted conflicting accounts, that is, scenario injects and dynamic inputs, which prioritized certain evidence, and attributed responsibility, this paper contributes to a growing body of work on socio-technical sensemaking. It also provides insight into the cognitive and communicative challenges students face when complex incidents are investigated — challenges that traditional cybersecurity curricula rarely address.

3.5. Learning Concepts

> "Untrained crisis teams have little chance of finding their way through the brave new world of contemporary crises. … Consequently, there is an ongoing need for training, not only to uncover flaws in regulations and emergency plans, but also by "shocking the organizations" by situations where they are not that robust. "[16]

This indicates that not just single-loop-learning as in lectures and case-studies should be provided for students, but instead a broader concept which adds case-training, simulations, serious games and socio-technical exercises. In addition, this suggests that learning should extend beyond acquisition of procedures. Argyris and Schön distinguish corrective learning within existing assumptions from deeper learning that questions the governing assumptions themselves [17]. The multi-loop learning model used here extends this logic to single-, double-, and triple-loop learning [18] previously adopted in research at the Norwegian Cyber Range-lab at NTNU in Gjøvik [6]. The adopted version is presented in figure 1.

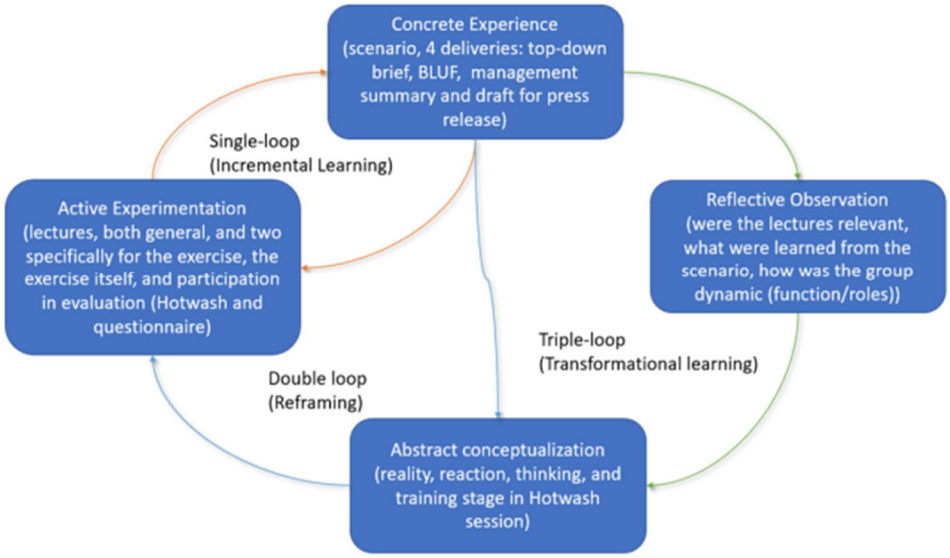


Figure 1: Pathways of and outcomes of single-, double- and triple-loop learning adapted from Medema Franklin Model [6], [18]

In this study, double-loop and triple-loop learning outcomes from the Krise i Syndstad serious game are analyzed to understand how socio-technical learning artefacts may support the learning necessary to meet investigative challenges in cybersecurity and other incidents.

3.6. Hotwash! As a Socio-Technical Change measure

Studies have found that Hotwash-sessions give good results after exercise as well as (of course) after incidents [19], [20]. Results have also shown that reasonable evaluations and reflections upon may lead to triple-loop-learning, that is, to actual changes in organizations. In this study, a Hotwash session was provided to the game-master-team, to understand if socio-technical changes would happen based on learning provided in the game.

4. Research approach

To meet the need to examine sensemaking in action: How students interpret ambiguous evidence, how they respond to contradictory accounts, and how they balance analytical reasoning with relational engagement, we have approached the challenges with a pragmatic philosophy and inductive approach. Where the scenario in the game is a case in itself, and results from interactions indulge students to 'ask to understand' and teachers (game-master-team) to act in roles to support learning goals. That is, interactive action research based upon socio-technical learning artefacts executed or injected in the game. As a follow-up step in the design science methodology (DSM) with an evaluation loop. The design science methods executed in this study of the *Krise i Syndstad*-game are presented as marked in red in figure 1. That is, to execute the Proper steps: Develop, Evaluation and Conclusion, the developed Artefact Output were tested and Performance measured to gain results to Develop and Evaluate.

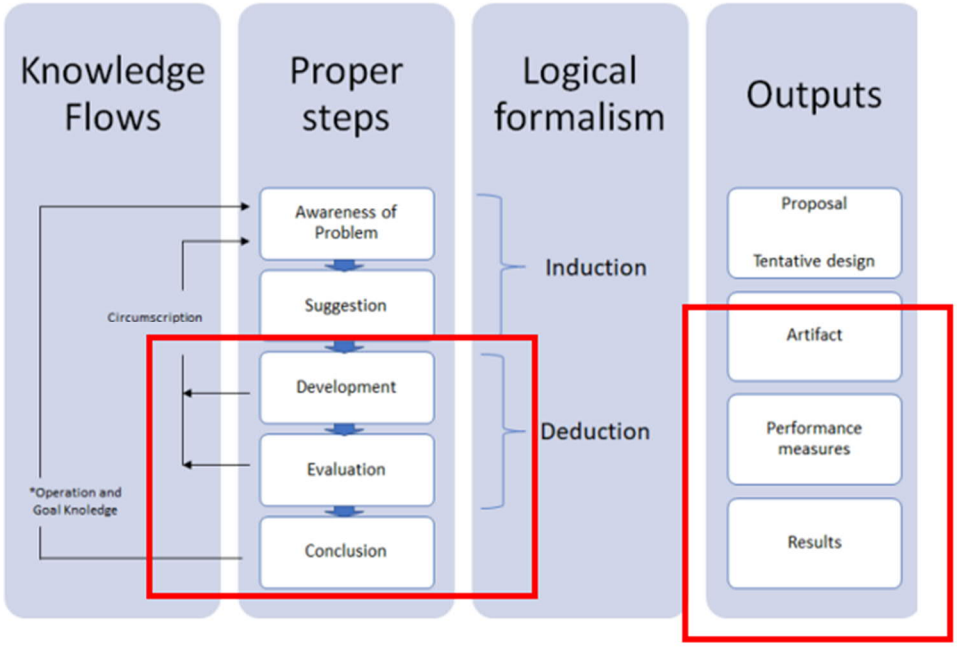


Figure 2: Design science methodology steps taken (Inductive formalism in Design science methodology adapted from Østby, 2023 [6]).

The purpose of this study was to evaluate how students engaged with the *Krise i Syndstad* serious game and to understand the learning processes that emerged during play. Whereas the original STPIS paper focused on the design rationale, this follow-up study adopts an empirical approach, drawing on multiple data sources to examine how students made sense of a complex socio-technical incident. Therefore, multiple mixed methods [21] have been used to meet the goals of this study.

4.1. Participants and Context

The game was deployed with Cyber Security students (bachelor's and master's students) enrolled in a postgraduate module on socio-technical systems. Students had prior exposure to technical incident response concepts but limited experience with organizational dynamics, investigative interviewing, or crisis communication. The game was run as a structured, time-bounded exercise during a scheduled teaching session.

4.2. Data Collection

Three complementary data sources were used to capture students' reasoning, investigative behavior, and reflections:

4.2.1. Pre-questionnaires

Administered immediately before the exercise, these questionnaires assessed students' baseline assumptions about incident causality, their expectations of stakeholder behavior, and their confidence in conducting investigative interviews. The pre-questionnaire served as a measure of initial mental models, particularly regarding linear versus systemic explanations.

4.2.2. Post-questionnaires

Completed after the exercise, the post-questionnaires captured students' perceptions of what they learned, the challenges they encountered, and how they understood socio-technical incidents had shifted. These responses provided insight into perceived learning outcomes and changes in reasoning patterns.

4.2.3. Open debrief with student-participants

A brief debrief capturing reflections from the groups was conducted immediately after the game, with particular attention to reductive causal reasoning, analytical interview techniques, and evidence-driven questioning. Secondly, interactive action research based upon socio-technical learning artefacts were collected from the scenario, from being interviewed by the students, and from 'journalist' interviews of the students. Action research can in a game consist of 1) plan, 2) act, 3) observe, 4) reflect and 5) re-plan in a spiral ongoing in the game if the game is structured with a dynamic approach. This may be visualized as presented by Kemmis et. al [22] in figure 3.

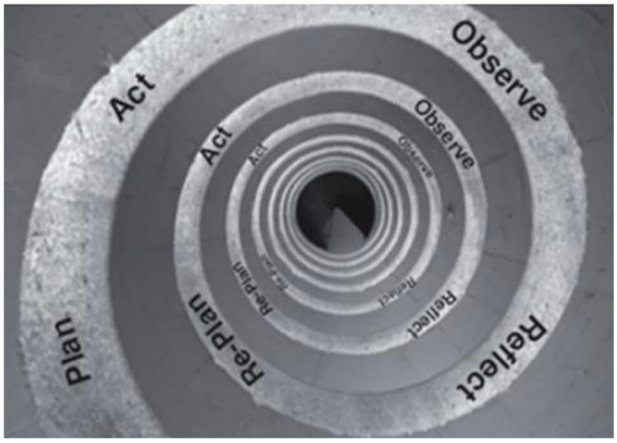


Figure 3: Action research spiral [22]

The socio-technical learning artefacts results in this game were collected from the game itself (second-loop learning) and from pre-questionnaires to the students and Hotwash! in the game-master-team/teachers (triple-loop learning).

4.2.4. Scenario

Krise i Syndstad was originally designed as a narrative-driven investigative simulation in which students interview municipal stakeholders, analyze documentary evidence, and reconstruct a multi-factor flooding incident. The design emphasizes ambiguity, partial information, and the interplay between technical, organizational, and political factors. In the initial STPIS paper[2], we described the game's architecture in detail; here, we provide a brief summary and highlight the modifications introduced for this deployment.

4.2.5. Core Structure

The game positions students as investigative teams tasked with understanding why a municipal response to severe flooding failed. Students receive evidence folders containing technical reports, emails, and operational documents, each containing omissions or contradictions. They then conduct timed interviews with non-player characters (NPCs) representing municipal departments such as infrastructure, ICT, emergency management, and finance. Each NPC holds partial knowledge, personal biases, and political constraints that shape what they disclose.

The game uses two contrasting inquiry modes:

- Team X – analytical, evidence-driven questioning
- Team Y – relational, empathy-based interviewing

This dual mode structure is designed to expose students to different investigative strategies and to highlight how communication style influences the information stakeholders reveal. Originally, these teams were divided into red-teams and blue-teams, and explanations had to be ensured, as the students at hand typically would know red-team vs. blue-team exercises like attackers vs. defenders' games. Explanations made initially in the game, hopefully (and

respectfully) led to little misunderstandings (we believe), but for later *Krise i Syndstad* games, changes towards 'good vs. bad' investigators will be made.

4.2.6. Modifications for This Deployment

Originally, the teams were divided into red and blue teams. To students who typically train to attack and defense in red- and blue-team exercises, this may have led to pre-assumptions of an, yes, exactly, attack and defense exercise. For this first full implementation, several changes were made to the original design to improve flow and manageability:

4.2.7. Replacement of NPCs

The original design included a larger cast of stakeholders. For this deployment, the NPC set was streamlined and rewritten to better align with the teaching context and to ensure consistent facilitation. Each NPC retained a distinct organizational perspective but was adapted to reflect local municipal structures and to simplify narrative coherence.

4.2.8. Journalist Role Instead of Wild Card/Deep Throat

The original concept included a "wild card" insider capable of revealing sensitive information if approached correctly. In practice, this was replaced with a journalist NPC, who served as an external pressure vector. The journalist introduced media framing, speculation, and reputational concerns, prompting students to reassess their assumptions and consider how public narratives shape crisis response. This change proved pedagogically effective, as it created a more realistic and immediately recognizable source of disruption.

4.2.9. Alternating Inquiry Roles

Rather than assigning teams permanently to X or Y roles, teams alternated inquiry modes across interview rounds. This allowed all students to experience both analytical and relational questioning styles. One team chose to adopt a hybrid "Purple Team" approach in the final round, blending techniques from both modes. This variation provided additional insight into how students conceptualized investigative strategy and how they adapted their communication style under time pressure.

4.2.10. Intended Learning Mechanisms

Across all versions of the design, the game aims to:

- expose students to contradictory evidence and incomplete information
- require them to integrate technical, organizational, and political factors
- highlight the role of communication style in eliciting information
- create conditions where sensemaking must occur under uncertainty
- encourage reflection on how investigative narratives are constructed

These mechanisms form the basis for the empirical analysis presented in the following sections. Our teaching approach to resolve this problem is to shift the thinking of professionals and students of cyber security, not to neglect logical and technical approaches, but to enhance their

socio-technical understanding and to employ empathy as a tool for both understanding and negotiating crisis situations and their investigation.

4.2.11. Debrief with students

The immediate student debrief examined how groups reconstructed the incident, which factors they emphasized or neglected, and how analytical and relational inquiry affected their interviews.

4.2.12. Hotwash! With game-master-team/teachers

A Hotwash with the game-master-team was conducted approximately two weeks later, allowing facilitators time for individual reflection. This session enabled facilitators/game-master-team (in reality, the teachers) to share their evaluation in a Hotwash-session, and examine any contradictions they had encountered, and discuss the interpersonal aspects of the interviews which they themselves participated in as actors in the game.

4.2.13. Learning procedure

To understand how the students adapted the learning goals, several means were executed. In addition, the game-master-team evaluated teaching means to understand the status quo of the game. A summary of the socio-technical collection of data to understand the procedure of learning from the game is presented in table 1.

Table 1
Socio-technical collection of data

Data-collection	Social/relational inquiries	Technical inquiries
Pre-questionnaire	8 of 9 questions empathic	1 out of 9 questions is from logic/technology
Participatory action research	5 participating as game-master-team -> acting action research	How students adapted to technical answers
Immediate debrief	2 main questions to discuss; analytical, evidence-driven questioning, and relational, empathy-based interviewing	
Post-questionnaire	7 questions are purely social, relational or organizational	2 questions are socio-technical integrated questions, and 0 questions are purely relational/technical

Hotwash!	2 ‘feeling’ questions, that is, 1) how you felt, 2) what would have made it easier for you, and 3) what YOU learned from the game.	5 rational/technical questions about thoughts and how to rationally move forward, and possibly indulge changes

4.3. Analytical Approach

Data were analyzed qualitatively using a pragmatic thematic approach appropriate to an exploratory IS evaluation [23]. Questionnaire responses, facilitator observations, debrief material, learning artefacts, and Hotwash reflections were compared for recurring patterns and contradictions. Coding focused on causal reasoning, attention to organizational and political factors, relational versus analytical inquiry, handling of contradictory evidence, and responses to uncertainty. Triangulation across sources was used to strengthen interpretive credibility rather than to claim statistical generalizability.

5. Findings and discussions

In this section findings from 1) pre-questionnaires, and 2) post-questionnaires are presented together with 3) findings from the socio-technical action research in the game, and finally 4) from the Hotwash-session.

5.1.1. Pre-questionnaires

The questionnaire presented to the students before the game are presented in figure 4, where the score from left to right is from 1) Strongly Disagree (SD), 2) Disagree (D), 3) Neutral (N), 4) Agree (A) to 5) Strongly Agree (SA).

Full Question (as written in the document)	1 (SD)	2 (D)	3 (N)	4 (A)	5 (SA)
1. "Incident investigations should primarily focus on identifying who made mistakes."	0	5	3	3	0
2. "Logical analysis and evidence are more important than understanding people's perspectives."	1	1	1	8	0
3. "Human error is usually the main cause of major incidents."	0	0	2	2	6
4. "Emotional reactions usually interfere with objective investigation."	0	1	2	7	0
5. "Understanding why decisions made sense at the time is important, even if they turned out badly."	0	2	1	4	3
6. "Building trust with stakeholders improves the quality of information gathered during investigations."	0	0	4	3	4

Figure 4: Pre-questionnaire form *Krise i Syndstad*

Across the cohort, the pre-game questionnaire revealed views only partially aligned with socio-technical perspectives. Students did not fully adopt a blame-oriented stance, yet their responses reflected a predominantly Safety-I, error-centric framing with limited attention to relational and organizational dimensions. While some rejected a blame-first approach, opinions were mixed, indicating incomplete understanding of systemic causation. Notably, most students

viewed human error as the main cause of incidents, reflecting traditional linear attribution rather than seeing error as a symptom of deeper system conditions.
Students also showed a strong preference for logical, evidence-based analysis over understanding people's perspectives. Many believed emotional reactions interfere with objectivity, suggesting a limited appreciation of emotions as indicators of stress or organizational pressure. In contrast, they demonstrated a clearer grasp of local rationality, recognizing the importance of understanding decisions in context. Views on trust were less developed, with several students unsure of its role in improving information quality, highlighting limited experience with interpersonal dynamics in investigations.
Overall, the responses indicate a technically oriented baseline, where investigation is seen primarily as analytical and procedural. Emotional and relational aspects were often viewed as obstacles rather than sources of insight, creating a self-reinforcing cycle of detachment and defensiveness. Although students identified objectivity and listening as important, these skills frequently broke down in practice due to premature conclusions and discomfort with emotional dynamics. This underscores the pedagogical need to challenge assumptions about emotion, communication, and causality in socio-technical investigation.
These baseline responses are important because they indicate not simply a preference for technical analysis, but a particular way of making sense of incidents. When confronted with uncertainty, students appeared inclined to reduce complexity by privileging evidence that could be organized into relatively direct causal explanations, while interpersonal and organizational information was less readily treated as investigative evidence. From a sensemaking perspective, this suggests that the students entered the exercise with established interpretive frames that shaped which cues appeared salient and plausible. The finding also resembles a Safety-I orientation in which investigation is directed primarily toward identifying failure, error, and deviation rather than understanding how interacting system conditions shape action. The purpose of the simulation was therefore not to replace analytical reasoning, but to disturb these initial frames sufficiently for alternative socio-technical explanations to become plausible.

5.1.2. Post-questionnaires

Across the post-game questionnaires, students showed a consistent ambivalence toward the role of empathy in incident investigation. The results from the first part of the questionnaire (1 – 9 which are scoring-questions…) are presented in figure 5, where the score on the right represented from left to right is from 1) Strongly Disagree (SD), 2) Disagree (D), 3) Neutral (N), 4) Agree (A) to 5) Strongly Agree (SA).

Table: Frequency of Responses (1–5) for All Six Questions

Full Question Text	1 2 3 4 5
"The game felt realistic and reflected the complexity of real-world incidents."	
("*1. The game felt realistic and reflected the complexity of real-world incidents.*")	0 0 2 5 5
"I noticed clear differences between logical questioning and empathetic questioning."	
("*2. I noticed clear differences between logical questioning and empathetic questioning.*")	0 1 2 6 3
"Empathetic communication improved the quality of information gathered."	
("*3. Empathetic communication improved the quality of information gathered.*")	1 1 2 5 3
"Blame or defensiveness reduced how much useful information was shared."	
("*4. Blame or defensiveness reduced how much useful information was shared.*")	0 1 3 5 3
"Trust influenced how willing stakeholders were to cooperate."	
("*5. Trust influenced how willing stakeholders were to cooperate.*")	0 1 2 4 5
"The game helped me think beyond single causes or single individuals."	
("*6. The game helped me think beyond single causes or single individuals.*")	0 0 1 6 5

Full Question Text	1 2 3 4 5
"7. This game changed how I think about incident investigation."	
("7. This game changed how I think about incident investigation.")	0 0 3 6 4
"8. I better understand the difference between blame and accountability."	
("8. I better understand the difference between blame and accountability.")	0 0 4 6 3
"9. I am more aware of how human, organizational, and technical factors interact in incidents."	
("9. I am more aware of how human, organizational, and technical factors interact in incidents.")	0 0 2 5 6

Figure 5: Results from post-questionnaires

While most participants recognized differences between logical and empathetic questioning, empathy had not yet become a trusted investigative tool. Some students agreed it could improve information gathering, while others remained neutral or skeptical, noting that interviews often devolved into blame or defensiveness. Short responses reinforced this pattern: some reported little change in their views, while others saw empathy as situational rather than essential. Overall, the game exposed students to interpersonal dynamics but did not fully shift their preference for logic-first approaches. Their stance remains transitional—they recognize empathy but do not yet rely on it—highlighting the need for stronger scaffolding.

Responses in Section B indicate a consistent learning effect across participants. Most agreed that incidents arise from interacting with human, organizational, and technical factors, and showed clearer distinctions between blame and accountability. Many also reported that the game changed how they think about investigations. Although the sample is small, the consistency suggests a shared shift toward systems-thinking and reflection on cognitive and organizational dimensions. Students appear to have integrated the idea that incidents rarely have a single cause, and that accountability can be addressed without blame.

The Q10–Q13 responses further highlight distributed socio-technical learning. Students identified both technical (preparation, questioning, process) and social (human factors, blame, communication) dimensions, with some bridging the two through recognition of roles, responsibilities, and complexity. Empathy was seen as conditionally useful but constrained by system dynamics such as defensiveness and blame culture. Interviews emerged as the key "bottleneck," where logic, empathy, and responsibility collided. Reflections on future practice showed two paths—stronger preparation and improved communication—with some students beginning to integrate both, indicating early development toward a more holistic investigative approach.

The post-game responses therefore suggest movement rather than conversion. Students appeared increasingly able to recognize incidents as products of interacting human, organizational, and technical conditions, while their investigative practices remained anchored partly in familiar logic-first approaches. This distinction is important from a sensemaking perspective: exposure to alternative cues does not necessarily mean that established interpretive frames are immediately replaced. Instead, the game appears to have created occasions in which existing assumptions became visible and contestable. The continued ambivalence toward empathy is particularly informative, because it suggests that recognizing interpersonal dynamics conceptually is different from treating relational engagement as a legitimate source of investigative knowledge.

5.1.3. Action research

Across the intervention, student learning can be understood as a Plan–Act–Observe–Reflect–Re-plan as presented in the action research spiral [22]. The cycle that reveals a gradual shift toward socio-technical thinking. In the planning phase of the game, students entered the game with a predominantly technical-rational and error-centric understanding, emphasizing logic, objectivity, and human error while undervaluing relational and organizational dynamics. During the action phase, they conducted interviews in a simulated investigation, where attempts at structured questioning were frequently disrupted by emotional dynamics, blame,

and defensiveness. Observation occurred as students experienced a mismatch between expectations and practice, particularly in interviews, which were repeatedly identified as the point where logic, empathy, and responsibility collided. In the reflection phase, students demonstrated increased awareness of human factors, system complexity, and the distinction between blame and accountability, although empathy remained a conditional and not fully integrated tool. Finally, in the re-planning phase, students proposed improvements that diverged between strengthening technical preparation (e.g., better planning and questioning) and enhancing relational skills (e.g., listening, patience, encouraging dialogue), with some beginning to integrate both. Overall, the cycle illustrates a transition from a predominantly Safety-I orientation toward an emerging, but still insecure, socio-technical understanding of incident investigation.

Seen as an action-research cycle, this transition is significant because the learning observed was not limited to acquiring additional investigative techniques. Students were confronted with situations in which their initial assumptions about evidence, objectivity, causality, and stakeholder behavior did not always produce the information or explanatory coherence they expected. Reflection therefore concerned not only what questions should be asked differently, but also the assumptions through which an incident was being interpreted. This provides tentative evidence of movement beyond corrective, single-loop learning toward the reframing associated with deeper learning. However, the continued uncertainty surrounding empathy and relational inquiry indicates that this reframing remained incomplete rather than representing a stable transformation.

5.1.4. Hotwash!

As teachers, or as in this case game-masters and facilitators, one seldom takes a 'how did this work for me' approach in an evaluation. Often, the evaluation takes place as a 'review-the-rest' approach, which in itself is ok, but not necessarily the best way to learn and possibly do changes necessary to the teaching artifact (in our case the *Krise i Syndstad* game). There are a couple of stages in a Hotwash-session necessary to 'get into' this form of evaluation, which is the feeling-phase and the thinking-phase. This psychological introduction was therefore adapted in our Hotwash-session, but thereafter the following stages were chosen (amongst all the Ebrahimian [12] stages) to reflect upon and possibly indulge (as responsible teachers are supposed to?) transformative change to the game (if necessary) as in the final learning-stage – triple-loop-learning.

As teachers and, as we may see, the 'feelings' varied from uncertainties, via stress to "happy with engagement". These are similar to reactions post-incidents and (from experiences are pretty normal in stressful situations. It might seem strange though, that the game-master-team should have these typical feelings one would have as participant in the game or an exercise, or as in an incident, and we suggest this also indicates necessary further studies upon the game-master-teams themselves. The 'feelings' are visualized in figure 6.

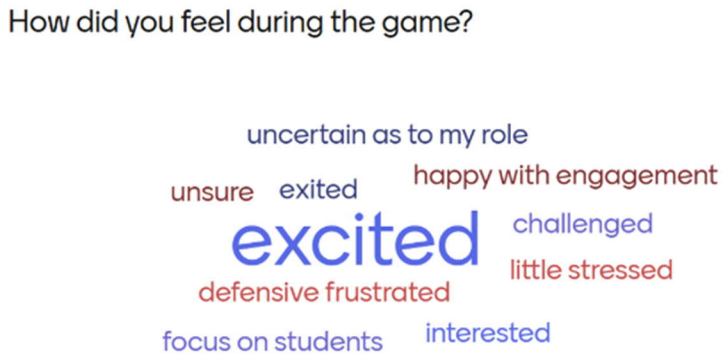


Figure 6: Feelings visualized

To reflect upon possible negative emotions, an 'uplift' question was introduced to both reflect further on the emotions, but also to understand what can be prepared better for the game-master-team till the next round of execution. As seen in the answers (figure 7), three main improvements suggestions emerged as 1) experience (which one now may find one has), 2) better understanding of the learning goals, and 3) pre-instructions (both to the game-master-team and to the students). Detailed instructions were given ahead of the game to the game-master-team however, which indicates that experience and training also for such roles would give a safer environment for the game-master-team itself. This has also been indicated in previous similar studies upon EXCON (exercise control)-teams [24].

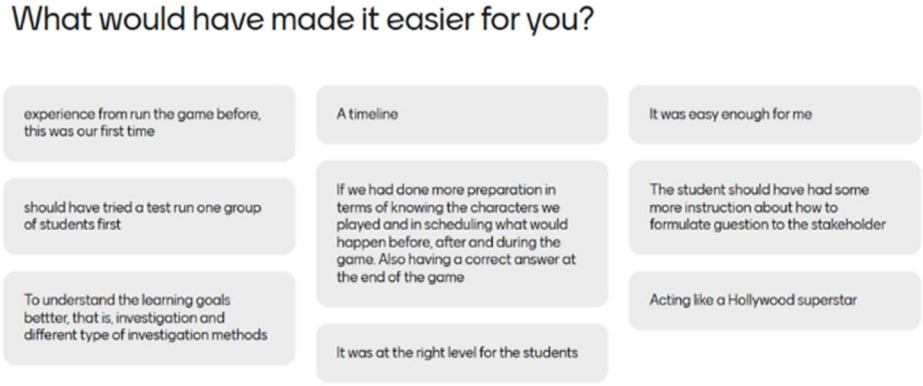


Figure 7: Improvement suggestions

Moving on to the 'thinking'-stage, the focus at hand is the scenario (in line with an incident). The thoughts vary mostly in two dimensions, from realistic as the main dimension, to extensive and complex in the other dimension. This too, is very similar to what participants in exercises experience [25]. Moving from 'feeling' to 'thinking' we therefore more than just can indicate that the game-master-team experiences the similar 'feelings' and 'thinking' as the participants in a game. Or as mentioned, in an exercise. Results from the first 'thinking-phase' are presented in figure 8.



Figure 8: First thinking-phase

A scenario may always be improved, and the question at hand is whether the scenario would be too extensive or too plain for the learning artifact at hand – a game play. The game-master-team in *Krise i Syndstad*, have however reflected upon two areas, which is 1) learning goals (how to do criminal investigation and cyber threat intelligence and technical forensic information), and 2) the roles and play of the game (contextualization of roles, therein invited experts, and students maturity level). This may indicate that it would be easier to be a good criminal investigator in such game if initial lessons were given. That is, single-loop-learning activities beforehand the game, which has been suggested in previous studies upon preparations to information- and cybersecurity exercises [26]. Secondly, roles and play may improve, but also in this regards, detailed instructions were given beforehand the exercise (both to the game-master-team and to the students upfront the start of the game). Moreover, one may for sure, be better off with actual expertise, though that would require extra time to involve and teach 'externals' as also presented in mentioned previous studies on EXCON-teams [24]. Suggestions for change in the scenario are presented in figure 9.



Figure 9: Suggestions for change in the scenario

At the stage of the Hotwash, the game-master-team were not yet presented with the learning outcome as presented in the sections above. As the team did conquer the Observe and Reflect action research phases in the game though, we suggest from the game-master-team's answers that learning goals were met, especially 1) investigation methods, 2) situational awareness and presentation abilities, 3) social and technical root-cause analysis. And specifically social empathic approaches alongside technical lenses. The game-master-team's suggested learning outcomes as presented in figure 10.

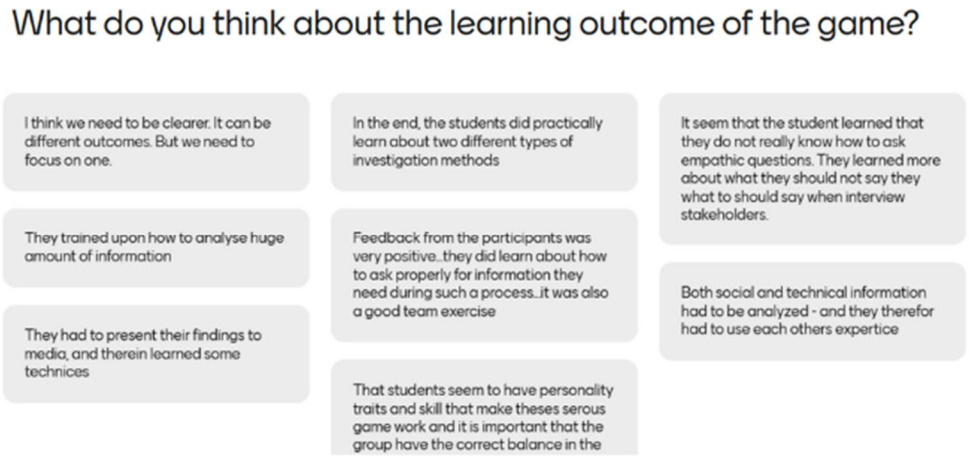


Figure 10: Master-game-team's suggested learning outcomes

Experiences from previous studies have indicated that what you yourself have learned in an exercise or a game, or even specifically from an incident, is one of the most difficult questions to answer [27]. So, to ask the question without supporting instructions may seem difficult. The answers however (figure 11), indicate that 1) to give learning feedback throughout the game may be beneficial, and 2) that students may not go in the 'direction' or towards the best practice investigation method suggested (learning goal). The latter may even indicate that the previous 1) learning feedback throughout the game, would help for such.

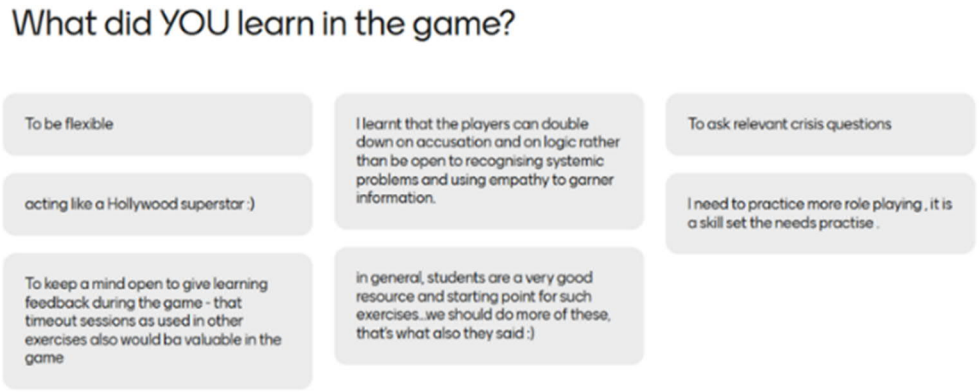


Figure 11: What the master-game-team participants found they learned

Your role is always where you can create impact – or as the best: Learning moments. That is, in the experience of the authors, in crisis-exercises - a shock may induce learning, and the shock may be given by you as the role-player. What we learn from the answers though, is 1) that the roles could have been more accurate in the terms of 'who am I' and not interfere with other roles and functions described in the scenario, and 2) options that are not in conflict with other roles, would be beneficial. The one desire to develop at chatbot for ones role may be an interesting aspect of a simpler more technical game, but not discharged as a part of a socio-technical game. Still, from real-life events, we do know social interactions will take place, and

that chat-bots are not there for your inconvenience if a real life event occurs. The master-game-team came up with changes to their roles as presented in figure 12.

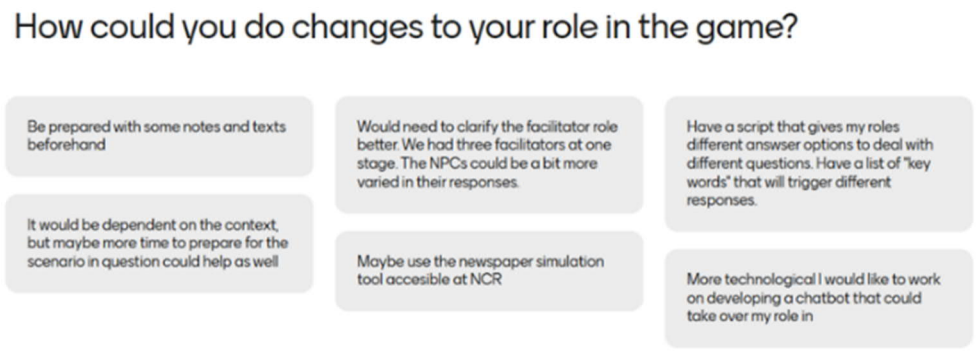


Figure 12: Suggested changes to roles

Finally, the transformational question is given – and therein, the question of if there will be changes in the next round? The answers (figure 13) suggest that 1) single-loop-learning artefacts should be implemented, that is, introductory scenario information upfront, 2) a tentative dynamic timeline with game-master lead is necessary, and 3) game-master-team role-support in the context of responses to follow-up investigative questions from the students. For the game one may try to implement the changes suggested, one may continue to run the game with suggested improvements and therein analyse whether the changes improved learning experiences and therein support transformational changes needed in socio-technical investigation techniques.

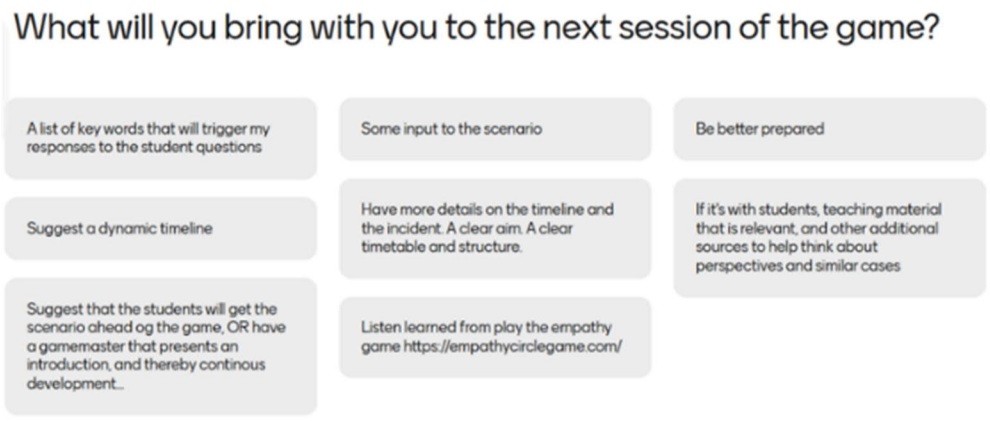


Figure 13: Desired changes for the next game

Taken together, the Hotwash findings suggest that experiential learning occurred on two interconnected levels. The game-master-team identified relatively immediate design adjustments, including clearer role definitions, preparatory material, and stronger facilitation structures, but they also questioned assumptions about how the game itself should produce learning. This distinction is relevant to the paper's account of multi-loop

learning: modifying instructions or timelines represents adjustment within the existing pedagogical design, whereas reconsidering the relationship between preparation, facilitation, role-play, and socio-technical learning begins to question the design assumptions themselves. The data do not establish that triple-loop learning has been achieved, but they identify conditions under which a subsequent iteration of the game could provide evidence of transformational change.

6. Conclusions

This study examined how students engage with socio-technical complexity within an ambiguous, multi-actor investigative simulation. The findings show that while Krise i Syndstad effectively challenges purely technical and linear reasoning, it does not automatically produce fully integrated socio-technical understanding. Instead, student learning remains transitional: participants begin to recognize complexity, interdependence, and the limits of blame-oriented explanations, yet continue to rely on familiar analytical habits under pressure.

Across the data, students demonstrated movement toward systems thinking, particularly in recognizing interactions between technical, organizational, and human factors and in distinguishing between blame and accountability. However, persistent challenges remained, including premature conclusions, difficulty handling contradictory evidence, and limited use of relational strategies such as empathy. Interviews emerged as a key "collision point," where analytical reasoning, emotional dynamics, and responsibility structures intersected, exposing gaps in students' readiness for real-world investigation.

Pedagogically, the study confirms both the value and limitations of serious games. The design successfully surfaces assumptions and promotes reflection, but deeper learning requires structured scaffolding, repeated practice, and explicit integration of relational competencies. The findings also highlight the importance of the game-master team, whose role and preparation significantly influence outcomes. Overall, Krise i Syndstad shows strong potential as a teaching tool, but must be embedded within a broader learning trajectory that develops both analytical and relational skills for socio-technical investigation.

7. Limitations

This study offers initial insight into socio-technical learning through serious games but has several limitations. It is based on a small, context-specific sample of cybersecurity students from a single institution, limiting generalizability to other settings. The data rely largely on self-reported questionnaires and qualitative observations, which are subject to bias and may not fully reflect actual behavioral change. In addition, the study captures a single, time-bounded intervention, meaning the observed "transitional" learning state may reflect early development rather than sustained competence; longitudinal research would be needed to assess longer-term effects. The dual role of researchers as designers, facilitators, and observers may also have influenced both student behavior and interpretation of results.

Further limitations relate to design variability and measurement challenges. Adaptations to the game, such as modified roles and inquiry structures, make it difficult to isolate which elements drove learning outcomes. At the same time, socio-technical constructs like empathy and sensemaking remain difficult to measure precisely, and the study emphasizes qualitative insight over quantitative evaluation. Finally, while student learning is the primary focus, other

elements of the socio-technical system, particularly the competence and preparation of the game-master team, are less systematically examined, despite their evident impact. Overall, the findings should be seen as exploratory but provide a useful foundation for future, more comprehensive research.

8. Future work

Future work should focus on understanding how socio-technical competencies develop over time and how they can be better supported through teaching. Longitudinal studies are needed to examine whether repeated exposure to Krise i Syndstad leads to sustained improvements in integrating analytical and relational approaches, particularly in empathy, sensemaking, and handling ambiguity. In addition, stronger pedagogical scaffolding should be introduced, including preparatory learning activities, guided reflection, and real-time feedback to help students connect experience with conceptual understanding.

Further research should also support systematic refinement of game design. Improvements identified in this study, such as clearer role definitions, enhanced instructions, and dynamic timelines, should be implemented and evaluated. At the same time, the role of the game-master team deserves closer attention, as facilitator preparedness and interaction strategies significantly shape the learning environment. To develop structured training for facilitators and to study their impact can strengthen the overall effectiveness of the simulation.

Finally, future work should expand both methods and scope. More robust assessment approaches, including behavioral and performance-based measures, are needed to evaluate socio-technical learning outcomes. Exploring digital or hybrid versions of the game may improve scalability, while deployments across disciplines and contexts can enhance generalizability. Overall, further research should continue to develop both the practical design of the game and theoretical understanding of socio-technical sensemaking, to contribute to a broader shift in cybersecurity education toward integrated technical, organizational, and interpersonal competencies.

Declaration on Generative AI

Any use of generative AI in this manuscript adheres to ethical guidelines for use and acknowledgement of generative AI in academic research. Each author has made a substantial contribution to the work, and it has been thoroughly vetted for accuracy, and they assume responsibility for the integrity of their contributions. In this study, AI (Copilot) is used to improve texts. AI-generated suggestions were critically reviewed by the authors, who retain responsibility for the accuracy, interpretation, and final wording of the manuscript.

References

[1] J. P. Cornelissen, ‘Sensemaking Under Pressure: The Influence of Professional Roles and Social Accountability on the Creation of Sense’, *Organ. Sci.*, vol. 23, no. 1, pp. 118–137, Feb. 2012, doi: 10.1287/orsc.1100.0640.

[2] R. McEvoy and S. Kowalski, ‘Crisis in Syndstad: A Serious Game for Post-Incident Investigation Training’.

[3] G. M. Vecchi, V. B. Van Hasselt, and S. J. Romano, 'Crisis (hostage) negotiation: current strategies and issues in high-risk conflict resolution', *Aggress. Violent Behav.*, vol. 10, no. 5, pp. 533–551, Jul. 2005, doi: 10.1016/j.avb.2004.10.001.
[4] A. Cherns, 'The Principles of Sociotechnical Design', *Hum. Relat.*, vol. 29, no. 8, pp. 783–792, Aug. 1976, doi: 10.1177/001872677602900806.
[5] E. Mumford, 'The story of socio-technical design: reflections on its successes, failures and potential', *Inf. Syst. J.*, vol. 16, no. 4, pp. 317–342, Oct. 2006, doi: 10.1111/j.1365-2575.2006.00221.x.
[6] G. Østby, 'Digital transformation of public security - developing triple-loop- learning artifacts to meet emerged information security incident response resilience and readiness challenges in public emergency organizations'.
[7] J. Andrew and M. Baker, 'Technological Impacts and Determinism in Technology Education: Alternate Metaphors from Social Constructivism', *J. Technol. Educ.*, vol. 3, no. 1, Sep. 1991, doi: 10.21061/jte.v3i1.a.4.
[8] E. Segers and T. Klemans, 'Technological determinism in educational technology research: some alternative ways of thinking about the relationship between learning and technology: Educational technology and determinism', *J. Comput. Assist. Learn.*, vol. 27, no. 5, pp. 373–384, Oct. 2011, doi: 10.1111/j.1365-2729.2011.00406.x.
[9] R. Bull, Ed., *Investigative Interviewing*. New York, NY: Springer New York, 2014. doi: 10.1007/978-1-4614-9642-7.
[10] A. Edmondson, 'Psychological Safety and Learning Behavior in Work Teams', *Adm. Sci. Q.*, vol. 44, no. 2, pp. 350–383, Jun. 1999, doi: 10.2307/2666999.
[11] C. Moumouh, J. A. García-Berná, M. Y. Chkouri, and J. L. Fernández-Alemán, 'Serious Games to Improve Privacy and Security Knowledge for Professionals: a Systematic Literature Review', *Int. J. Serious Games*, vol. 12, no. 1, Feb. 2025, doi: https://doi.org/10.17083/ijsg.v12i1.825.
[12] K. Amjad, K. Ishaq, N. A. Nawaz, F. Rosdi, A. B. Dogar, and F. Khan, 'Unlocking Cybersecurity: A Game-Changing Framework for Training and Awareness—A Systematic Review', *Hum. Behav. Emerg. Technol.*, Feb. 2025, doi: https://onlinelibrary.wiley.com/doi/10.1155/hbe2/9982666.
[13] K. E. Weick, K. M. Sutcliffe, and D. Obstfeld, 'Organizing and the Process of Sensemaking', *Organ. Sci.*, vol. 16, no. 4, pp. 409–421, Aug. 2005, doi: 10.1287/orsc.1050.0133.
[14] D. P. Mcadams, 'The Problem of Narrative Coherence', *J. Constr. Psychol.*, vol. 19, no. 2, pp. 109–125, Apr. 2006, doi: 10.1080/10720530500508720.
[15] R. Murimi, S. Blanke, and R. Murimi, 'A Decade of Development of Mental Models in Cybersecurity and Lessons for the Future', in *Proceedings of the International Conference on Cybersecurity, Situational Awareness and Social Media*, 2023. doi: https://doi.org/10.1007/978-981-19-6414-5_7.
[16] P. Lagadec, 'Learning Processes for Crisis Management in Complex Organizations', *J. Contingencies Crisis Manag.*, vol. 5, no. 1, pp. 24–31, Mar. 1997, doi: 10.1111/1468-5973.00034.
[17] Ch. Argyris and D. A. Schön, 'Organizational Learning: A Theory of Action Perspective', *Reis*, no. 77/78, p. 345, 1997, doi: 10.2307/40183951.
[18] W. Medema, A. Wals, and J. Adamowski, 'Multi-Loop Social Learning for Sustainable Land and Water Governance: Towards a Research Agenda on the Potential of Virtual Learning Platforms', *NJAS Wagening. J. Life Sci.*, vol. 69, no. 1, pp. 23–38, Jun. 2014, doi: 10.1016/j.njas.2014.03.003.
[19] J. Vykopal, R. Ošlejšek, K. Burská, and K. Zákopčanová, 'Timely Feedback in Unstructured Cybersecurity Exercises', in *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, Baltimore Maryland USA: ACM, Feb. 2018, pp. 173–178. doi: 10.1145/3159450.3159561.

[20] A. Ebrahimian, S.-M. Esmaeili, A. Seidabadi, and A. Fakhr-Movahedi, 'The Effect of Psychological Hotwash on Resilience of Emergency Medical Services Personnel', *Emerg. Med. Int.*, vol. 2021, pp. 1–7, Aug. 2021, doi: 10.1155/2021/4392996.
[21] M. Sounders, P. Louis, and A. Thornhill, *Research methods for business students*, vol. 5, 5 vols. Edinburgh Gate Harlow Essex CM20 2JE England: Pearson Education Limited, 2009.
[22] S. Kemmis, R. McTaggart, and R. Nixon, *The Action Research Planner: Doing Critical Participatory Action Research*. Singapore: Springer Singapore, 2014. doi: 10.1007/978-981-4560-67-2.
[23] E. Wynn and H. Vallo Hult, 'Qualitative and Critical Research in Information Systems and Human-Computer Interaction', *Found. Trends® Inf. Syst.*, vol. 3, no. 1–2, pp. 1–233, Jun. 2019, doi: 10.1561/2900000014.
[24] G. Østby, B. Emil Selebø, and S. Kowalski, 'Training the Trainers for Cybersecurity Exercises - Developing EXCON-teams', presented at the 14th International Conference on Applied Human Factors and Ergonomics (AHFE 2023), 2023. doi: 10.54941/ahfe1003725.
[25] G. Østby and S. J. Kowalski, 'ORGANIZATIONAL LEARNING WITH CRISES – TRIPLE LOOP LEARNING IN CYBER SECURITY EXERCISES', presented at the 14th International Conference on Education and New Learning Technologies, Palma, Spain, Jul. 2022, pp. 5215–5224. doi: 10.21125/edulearn.2022.1235.
[26] G. Østby and S. J. Kowalski, 'Preparing for Cyber Crisis Management Exercises', in *Augmented Cognition. Human Cognition and Behavior*, vol. 12197, D. D. Schmorrow and C. M. Fidopiastis, Eds, in Lecture Notes in Computer Science, vol. 12197. , Cham: Springer International Publishing, 2020, pp. 279–290. doi: 10.1007/978-3-030-50439-7_19.
[27] G. Østby and S. J. Kowalski, 'Hendelseshåndtering ved cyber- angrepet mot Østre Toten kommune'.