Chapter 10

Public Awareness and Education for Flooding Disasters

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Additional information is available at the end of the chapter

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Abstract

In recent years, dramatic river flooding occurred in the city of Prague causing the raising of the river water level more than 8 m and the inundation of the lower parts of the city. The disaster resulted in numerous casualties and damages of buildings and infrastructures. Prior disaster analysis showed that the city was not well prepared for facing the disasters. A digital training could be a powerful tool for increasing knowledge and awareness of the citizens and providing training facilities about response to such disasters. A special Massive Open Online Course (MOOC), therefore, has been developed focused on flooding in Prague offering educational material in crisis flooding. Dedicated technologies have been developed such as a flooding alert and a nonverbal communication language based on icons. The MOOC enables participants to train the new technologies. Participants can also play roles in the crisis management team to increase the sensitivity of the complexity of a flooding crisis and its measurements. The first prototype of the MOOC was tested on a group of students of the Technical Universities of Prague and Delft. The test results will be reported.

Keywords: crisis awareness, MOOCs, dynamic routing, flooding disasters, serious gaming

1. Introduction

In the summer of 2002, there was a heavy rainfall in the central part of Europe [33]. Typical rain rivers, Danube, Elbe, Labe and Vltava had to transport an amount of water far beyond their capacity. Many dikes along the rivers were breached and large areas were inundated. There were hundreds of victims and great damages to buildings, properties and infrastructures. Old cities as Dresden and Prague were heavily affected and large parts of the cities were inundated.

As reported in [6, 32], the analysis showed that the crisis management teams on central and local level of the city were not well prepared for flooding disasters. Moreover, citizens were not aware of the complexity of a flooding disaster. For the city of Prague, the shortcomings can be summarized as follows:

- *Incomplete crisis plan*. A crisis plan was designed and many plans proposed, such as to improve the infrastructure of the city, to strength the dikes along the river, to broaden and deep the riverbed and to create buffers for raising water. Some of these plans were realized but many of them are still waiting for execution. However, some years after a disaster, there was a reduced fear of flooding and costly plans were postponed.
- *Complexity of a flooding disaster*. Many citizens underestimated the power and speed of the raising water. Instead they responded not until it was too late. However, series of events during a flooding disaster could be related to each other. For example, closing the possible inundated metro lines in time could impact evacuation possibilities of citizens.
- *Opposing interest*. To reduce the amount of water in the Vltava, confluent streams could be blocked by dams. This would cause flooding along the confluent streams. To protect the old town, other areas could be inundated on purpose. Such a decision was not always appreciated by people living in inundated areas.
- *Individual versus group decision*. During a disaster, the management team has to take group decisions conflicting individual interest, perception and behavior. In the case of mass evacuation, for example, the analysis showed that some individuals stayed behind until the very last moment and caused problems later on.
- *Communication problems*. Prague is an international city housing many citizens and visitors from abroad who do not master the Czech language. On the other hand, social media has showed their important role during a crisis. It is a great challenge of the management team to get involved in communication via social media.
- *Lack of training*. First responders have organized exercises and trainings at regular times. However, big disasters as flooding can only be simulated. A difficult aspect is how to involve citizens in such disaster trainings.
- *Flow of events*. As mentioned above, events during a flooding disaster could result in and impact other series of events. Therefore, measurements of the management team should be taken in time and not all at once. On the other hand, time and resources are usually limited.

Immediately after the flooding disaster the focus was on repatriation of people and repair of damage to buildings and infrastructures. New plans were developed to control the raise of the water. One of the plans was to build dams in the river Vltava and to create lakes in front of the dam. These lakes can be used to buffer raising water during a flooding disaster. Much effort was spent to improvement of the disaster plans. Lessons learnt for the previous flooding disaster were implemented in the new plan. However, the crisis management realized that the execution of a disaster plan would require much training of all involved people. On the other hand, to increase crisis awareness of citizens and to organize training for new developed technology is far from trivial.

One of the new developed technologies is a crisis app [7, 9, 10, 29, 30]. Every citizen in Prague can download such an app on his smart phone. The app supports communication between citizens and crisis management team. To train the use of the app special training events have to be organized. Serious gaming, simulation and MOOCs enable the training of such tools. In this chapter, we discuss the development and use of a dedicated MOOC focusing on the flooding disaster of the river Vltava in Prague. The goal of this chapter is to solve the following research questions:

Q1: *Is it possible to use the digital learning material to learn people about crisis management?*

Q2*: Is it possible to increase crisis awareness and commitment by playing different roles in the crisis management team during a simulated flooding disaster?*

Q3: *Is it possible to improve the understanding of the complexity of a flooding disaster and improve the mastering of abilities by training of citizens by following the course?*

The outline of the chapter is as follows. In the next chapter related work will be presented. In recent years, many papers have been published considering the option of serious gaming and digital learning in crisis education. We continue this chapter by describing the general outline of the MOOC and its contents, namely: the developed crisis app, flooding icon-based communication, and crisis management game. Further, we present experiments, survey research and their results. Finally, we end this paper with conclusions and future work.

2. Related work

In recent years we published some papers on the flooding MOOC on learning conferences [24–28], which were focusing on presenting MOOCs as a new didactical learning tool. The content of the course and especially the crisis aspects were hardly discussed. On the other hand, the International Federation of Red Cross and Red Crescent Societies have used MOOCs to enable participatory, collaborative learning by engaging participants in discovery and problem solving for disaster risk reduction [17]. This form of distant learning was one of the implementation of key approaches that were formulated in the guide on public awareness and public education for disaster risk reduction published by this organization [16]. The key approaches were campaigns, participatory learning, informal education and formal school-based interventions. The guide provided an overview of all performed experiments. It has promoted National Societies to make specific choices in developing educational tools and set up their own experiments. The focus of the development was on approaches and tools for public awareness in disaster risk reduction.

Other attempts have been done on developing MOOCs in the field of crisis management. Bacon et al. [2], for example, presented a paper on the design of an immersive online crisis preparation learning environment and promoted MOOCs as a training tool. The chapter was based on three European-funded research projects, namely Pandora [21], dCCDFLITE [8] and POP-ALERT [22], which focused on the preparation of societies and populations to cope with crises in rapid, effective and efficient way. A MOOC platform had been developed to support crisis training of the public on a large scale on an earthquake disaster and a fire disaster. The MOOC was developed based on a survey study that highlighted the cognitive processes of people during the onset of a crisis and factors having an impact of decisions and behavior of people during a crisis. It should be available for general public from 2016, but unfortunately the project had some delay.

The MOOC developed by Beach [4] from the University of Pittsburgh on the Coursera platform provided at least five courses related to crisis management. The courses were intended for individual students who want to develop core competencies of disaster readiness and survival planning various natural disasters, such as flooding, tornado, hurricane, tsunamis and earthquake. The developer took an assumption that many people living in areas threaded by disasters looking for possibilities to increase their knowledge and abilities for crisis survival. Another example of a MOOC in this field was developed by Hostettler [16] from Ecole Polytechnique Federale de Lausanne. The MOOC taught science and techniques for reducing disaster risk and increase resilience during chemical hazards, floods, landslides and earthquakes. The goal of this MOOC was teaching relevant technologies in a relevant context. Students were tested on their increase of knowledge and less on acquired abilities. On the other hand, a MOOC developed by Leaning and VanRooyen [19] from Harvard University prepares participants to recognize and analyze emerging challenges in the humanitarian work during crisis response.

MOOCs could also be used for training existing software tools for crisis management. At the ISCRAM conferences many authors presented tools which could be used for communication during a crisis or to support evacuation. Some of these tools have been tested in real-life experiments but most of them were tested in simulation studies. Some of our previous works presented in these conferences were in the field of dynamic routing and nonverbal icon-based communication [9–13, 23]. Another project that focused on developing services and tools for emergency and civil security organizations for training and crisis management was the Indigo project [1]. Within this project, research and testing of other existing software tools for crisis management were also reported. Two of the tools were CRIMSON and Hazmat. CRIMSON was a system that combined latest simulation and virtual reality technology [3]; Hazmat was a hot zone-networked multiplayer simulation [20], where responders could be trained in emergencies with chemical and hazardous material emergencies.

Furthermore, we consider applying serious gaming approaches on our MOOC design. Serious gaming is ideally suited to developing new insights into complex situations such as crisis situations, experimentation, and education and training of people working in these

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complex environments. Based on this, in [5], we discussed the use of serious gaming in the training of first responders during a crisis event. The serious gaming was developed based on dynamic scripting to replace the static linear flow of events by a dynamic mixture of events.

The proposal of using scenario and serious gaming during a crisis simulation was initiated by Walker [34] from RAND/European-American Center for Policy Analysis. He stressed the fact that course of events would be difficult to predict during a crisis. As a crisis would be developed in the course of time, momentary decisions would have their impact on the rest of the course. A realist interactive game design would almost be impossible. The only option would be to provide scenarios and gaming with predefined decisions and consequences based on analysis of historic disasters.

The Hague Security Delta [31] has used a serious gaming technology to train professional and managers to protect critical infrastructures during disaster events. Based on the results of these trainings, the company showed that serious games could also be used for increasing crisis awareness and developing innovative theories [15, 35].

A game on Dutch flood risk management has been developed by Janssen [18, 34] to train actors in the assessment of measures which could reduce flood risk and limiting the impact. To visualize the consequences of human intervention and the effect of flood reducing measures, the author developed a simulation of the flooding and inundation of large areas using an area around the harbor of Amsterdam as a case study. The research showed that by playing the flooding game, the awareness of parameters influencing flooding disaster of players were increased. This game provided an environment to cooperate to realize common goals.

Another game for training decision makers in managing crisis was developed by researchers from Thales, T-Xchange and TNO in the framework of the research program Game Research for Training and Entertainment (GATE) [14]. It involved a role of a mayor of a city. Many mayors were willing to provide their knowledge, with which a mayor had to master in his daily management job facing important issues and dilemma's a mayor has to master in his daily management job in the city. To test the game, training facilities were developed by the T-Xchange company at the campus of the University of Twente in the Netherlands. One of the facilities offered was an augmented reality device using Google Glass. These facilities provided real time crisis simulation involving rescue workers and were used to perform and to test a number of serious games developed by the research program.

Instead of using training facilities, we aim at training first responders and civilians in managing crisis using a combination of the serious game approach and previous developed simulated tools using a MOOC. The goal of the MOOC is to increase crisis awareness and relevant abilities, which usually could only be done by time-consuming and costly training exercises. The dynamic scripting is applied on a role play game where participants of our MOOC will be confronted with outcomes of their management decisions from a list of possible options.

3. Model

In this section, we describe a selection of our developed learning modules that provide a main contribution to the crisis awareness, crisis knowledge, development of crisis abilities and offering training facilities. We will also present the implementation of the modules and the use of didactic approach.

3.1. Learning module development

Participants of the MOOC will be a member of a crisis management team. Solving problems and taking management decisions will confront participants with ongoing events during a flooding disaster. Furthermore, previous experimental results showed that the MOOC could generate high feeling of presence and involvement of participants in the flooding disaster [26]. A great difference with classical e-learning is that MOOC students are free to enroll (anonymously) in the MOOC course without enrolling as a student to the home University. Given the expected great numbers of participants, teachers are not present prominently.

The modules of the MOOC have been implemented using Moodle, a well-known open-source platform for developing and distributing digital learning material. Moodle is a tool to develop classical digital learning modules divided into learning material in categories and courses and equipped with quizzes or assignments. More advanced platforms and learning communities offer more advance training modules and support. In the past, we had some experience with *edX*. However, to be a member of the learning community requires a yearly significant contribution. The goal of the current course was to develop the course by low budget means. This course should inspire members of the Czech Technical University network and to develop MOOCs, which should be available for all partner universities. Furthermore, Moodle opens up possibilities to develop more advanced tools and to make these available for the Moodle community.

We found that one of the difficult problems in developing a MOOC was to organize cooperation between students. This was because of the following reasons: (1) Many students prefer to study individually rather than in a group; (2) The student population participating in the MOOC is rather heterogeneous with respect to age, education, background and abilities; (3) Cooperation via social media is difficult to organize in distant learning on a large scale; and (4) Compared to regular students most students involving in MOOCs have no direct relation to each other and there is usually a great group of left-overs not participated in cooperative groups [27]. Therefore, the integration of social media and group interaction is still under development.

Another problem with the use of MOOCs is the high dropout rate [25]. It is a great challenge to motivate students in such a way that they keep on board. We approach this problem using an interactive learning environment and a focus on application oriented learning using simulations. One of the ideas is by the use of inquiry-based learning [28]. The approach requires

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students to pose questions during learning instead of having answers to questions. A reminder to pose questions is sent at regular times to the students. A dedicated software has been designed to put these questions on a bulletin board as most frequently asked questions. Some of these questions will be answered or discussed by other students. But the main idea of generating questions is to improve the alertness of students during learning.

3.2. Social media

Social media play an important role during a flooding crisis. Citizens in Prague or people staying in Prague share their observations and emotions via social media (**Figure 1**). Management crisis team can use this information posted on social media to improve the context awareness, to detect signs of panic in the community or to assess ongoing topics and for supporting the decision-making process.

The crisis team has less control over the communication. To sort the tweets on Twitter, the management team could introduce the hashtag`#flooding` and post some tweets in the hope that people will post their tweets using the same hashtag. Information posted on social media can be very subjective, full of misperceptions or even faked news. Tweets #1 and #2 in **Figure 2(a)** contain probably contradictory information. However, this occurs due to the hilly landscape of the city of Prague. It could happen that valleys were full of water and the hills were still dry. Furthermore, below the surface of Prague there are many caves and sewage, transporting the water below the barriers.

Many Czech speaking people staying in the city of Prague. But also many foreign tourist staying in Prague, who are speaking many languages except Czech (**Figure 2(b)**). These tourists could send their messages with observation to the crisis center and vice versa. They

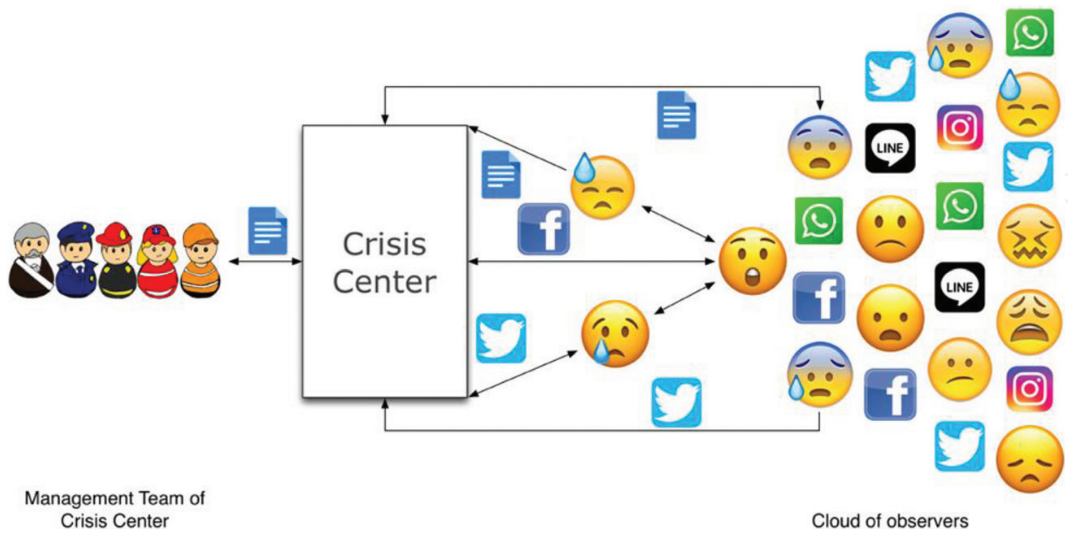

Figure 1. Cloud of observers communicating via social media.

(a) (b)

Figure 2. People in the city are able to use an app to send their observations to the crisis center: (a) tweets and (b) multi-language messages.

Raise of water	Flooded river bank	Flooded city area	Sinking boat	Drowning person	Injured person	Disabled
Drowning animal	Shelter	Medical assistant	Ambulance	Police	Fireman	Technician
Bad weather	Metal Barrier	Evacuate	Cutting Electricity and water	Sandbag Barrier	Request	Flooding news-site crisis map

Table 1. List of icons in the flooding language.

will receive emergency messages from the crisis center or from people in the shared disaster area. It is impossible to do this in all available languages, therefore, there is a need to use a dedicated nonverbal language. We developed in the past a crisis language with a dedicated syntax and grammar [11–13, 19]. The idea was to convert a sentence in natural language to a string of icons automatically. Many icons and grammar rules were needed. In the current approach, we applied the icon language to the flooding situation and we converted observations to a string of icons directly without natural langue as an intermediate step.

A flooding is a typical natural disaster with specific events, which can be symbolized by icons (**Table 1**). People in the city can send messages, composing a string of icons via the crisis app using the icons from the flooding language. A GPS coordinate and time stamp will automatically be added to the message. In the crisis center all the icon messages will be interpreted and converted to natural language sentence. An icon message is usually ambiguous or incomplete. However, we have to consider such a message in the crisis context (**Figure 3**).

3.3. Evacuation during a flooding disaster

One of the most difficult events is to organize an evacuation from the lower parts of Prague. It has involved about 500,000 citizens, who have to be evacuated in time before the area will be flooded. As presented in Section 3.2, a dedicated app with an icon-based flooding language has been designed to enable the citizens and the crisis center to communicate with each other and can be used during the evacuation process. However, citizens tend to postpone evacuation to the very last moment, because people do not want to leave their houses and properties behind without supervision. Another problem is that the situation is changing dynamically that requires a very flexible and adaptive evacuation plan. In the framework of the MOOC, we developed a dedicated adaptive routing device enabling pedestrians to route to shelters or safe areas [23]. This section describes this routing device in more details.

Figure 3. Mobile messages sent in the form of text, photograph and icon message that convey the same meaning in the context of flooding disaster.

Nowadays, people are familiar using route planner software on their smart phone to navigate them to a certain destination. The app receives the position of the user at regular times. Therefore, the system is able to track the user and computes the traveling time between way points. A navigation system usually uses a well-known shortest path algorithm for a static environment, such as Dijkstra's algorithm, to compute the shortest path from start destination. During a flooding disaster, people can use the navigation app to route them to safe areas. However, during such a disaster, streets could be inundated, tunnels could be closed and bridges could be collapsed. The pedestrian on their way to safe areas have to adapt their route or even have to return if the upcoming water blocks their route. Even, local citizens of Prague may not know how to go to safe areas in such conditions. In addition, if many pedestrians use the same route, congestions can occur and it takes more time to walk along the route.

We developed a dedicated flooding app that was equipped with a navigation system. The system displays flooding events on a map and an arrow showing the direction to a safe area/ shelter (**Figure 4**). The map is dynamically updated in case of upcoming water. Similar to the route planner in Google, the system uses a shortest path from current location to safe area. For this purpose, the street network of the City of Prague is visualized as a graph with crossings as points and streets as connecting edges. Given a starting point and a destination point, the system can compute the shortest path and route the user along this path based on the static

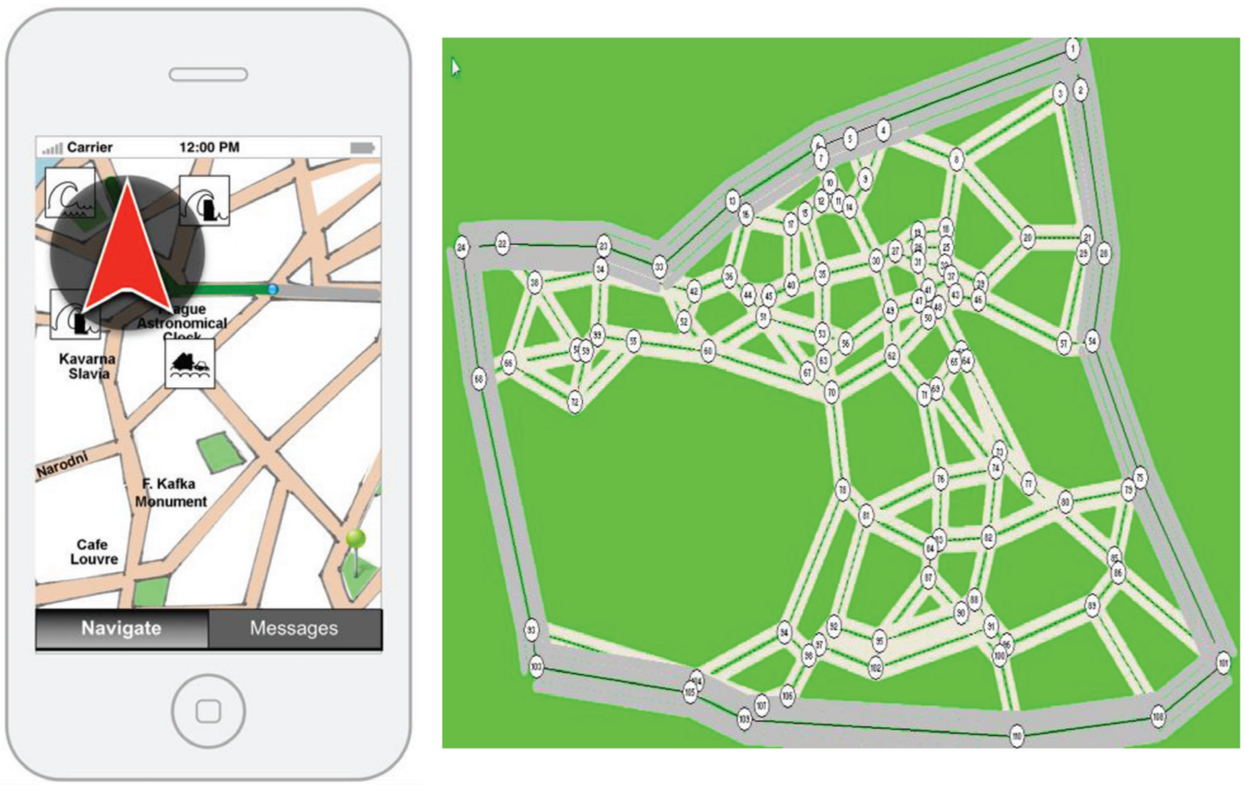

Figure 4. Navigation on the flooding app and the graph representing the street network of the city.

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t	A-B-D-E	A-C-D-E	A-E
00.10	Blocked	Blocked	30
00.05	Blocked	25	30
00.00	23	25	30

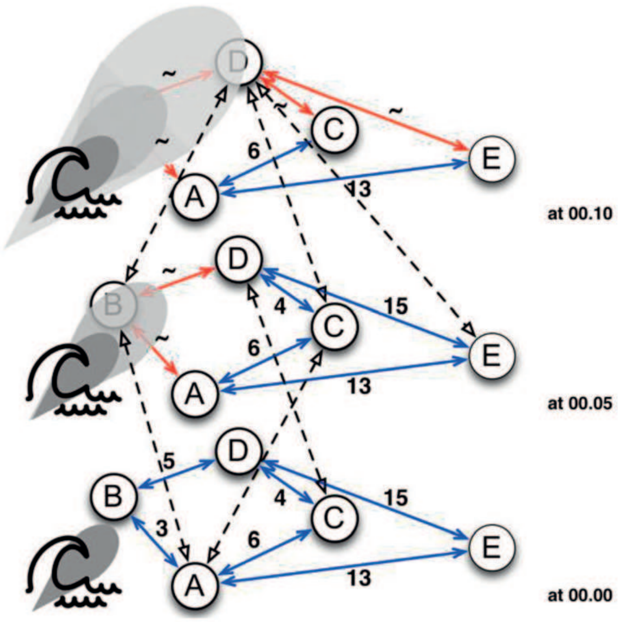


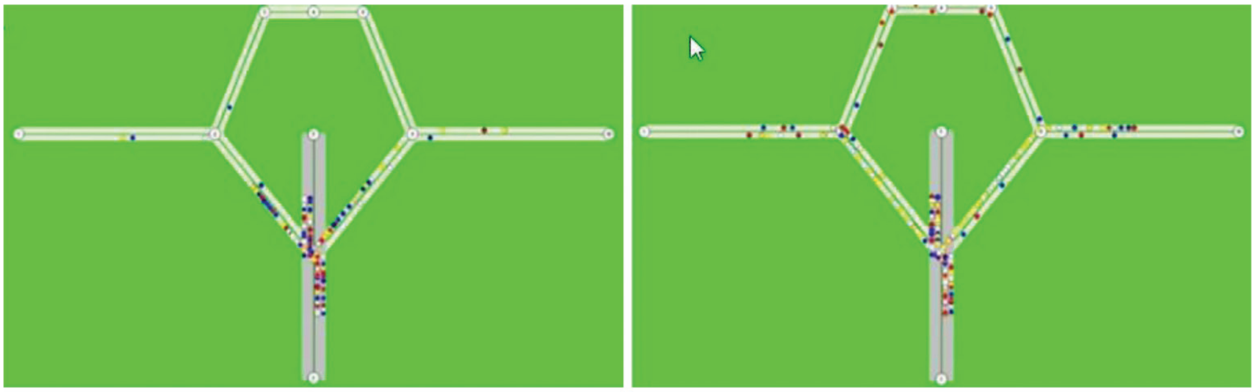
Figure 5. Visualization of the dynamic routing algorithm.

routing algorithm. However, during a flooding disaster, a dynamic routing algorithm is needed.

To apply the dynamic routing algorithm, the app receives observation reports that are sent by people in the area. Using this information, the app is able to update the availability of each route and the map dynamically. Let us consider five locations on the city map: A, B, C, D, E and assume the point E is the safe area. **Figure 5** displays the computation results of the walking distances from A to E (in minutes) along different path. At each cycle, the algorithm calculates multiple versions of a particular annotated graph. Each graph represents the situation at a particular time t with 5 minutes interval with blue edges representing available routes. In this example, A-B-D-E is the shortest path at t = 00.00. The illustration shows that upcoming water has threatened B at t = 00.00 and completely blocked this point at t = 00.05, which result in A-C-D-E is the shortest path at t = 00.05. However, since the upcoming water is then also threatening D and completely blocked this point at t = 00.10, the paths D-C and D-E become not available from A. At t = 00.10 the shortest route is A-E. This example shows that at regular time steps, that is, 5 minutes, the shortest routes are computed via the links and using the eventually updated links in the graph. The final output is the path A–E.

3.4. Simulation in the flooding MOOC

The developed MOOC uses movies and simulations to provide a high feeling of presence of a flooding disaster. The current version employs many YouTube movies to provide a realistic

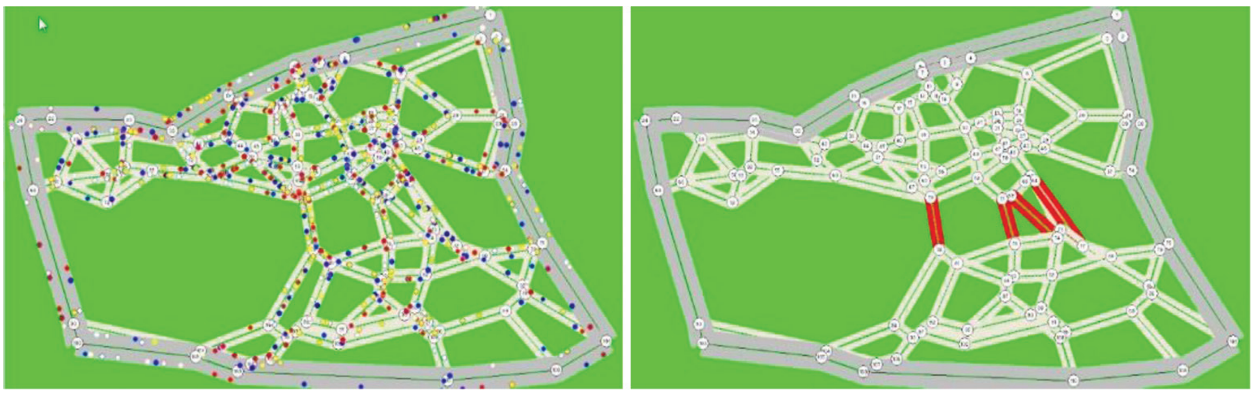


(a) (b)

Figure 6. Routing simulation: (a) bottle neck in the south and (b) rerouting to the northern route.

visualization of the crisis. On the other hand, the simulations are used to allow a virtual participation in such a crisis. In the following, we illustrate the use of simulation using two examples. These examples show the kind of problems that the crisis management team has to solve. By being a member of the management team and participating in the simulations, we expect the participants become aware of the problematic situations.

Figure 6 shows an example of routing problems of people on their way to safe areas. The problem for the management team is that sometimes they have to take measurements which give optimal routing for the whole cohort of people on the cost of individuals. Many individual people use an egoistic approach instead of an altruistic approach. In this example (**Figure 6(a)**), car drivers prefer to use the southern route, because this is the shortest and preferred route. It appears that a congestion appears in very short time. Car drivers are unaware of the fact that they also can use the northern route in time. When some drivers use the northern route, this results in an optimal flow through of the whole cohort of drivers as shown in **Figure 6(b)**. The



(a) (b)

Figure 7. Routing simulation: (a) moving pedestrian and (b) blocked bridges.

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management team can take regulations to invite car drivers to take the northern route in time or even force them to do so.

Figure 7(a) displays a simulation of moving pedestrians in the city as moving pixels; whereas, **Figure 7(b)** shows a simulation when we disable the crossing of three bridges. In this situation, members of the management team have to predict the movement of pedestrians in the new situation and define regulations to route them in an optimal way.

3.5. Management flooding game

To increase knowledge and perception of a flooding crisis, to increase awareness of what is going on during such a crisis and to increase the knowledge and abilities, at regular times the crisis management of the city organizes training sessions for first responders. However, a flooding disaster is difficult to organize in real time. Therefore, the management could train the first responders in the execution of the crisis plan based on scripts. On the other hand, a

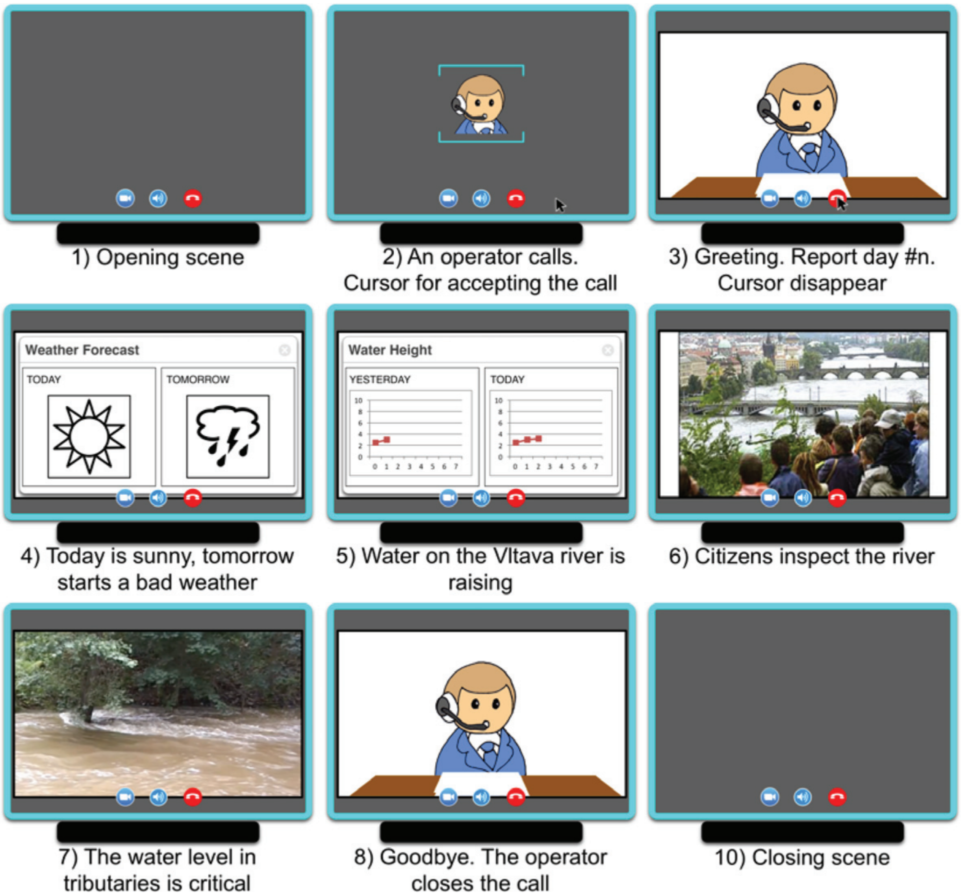

Figure 8. An example of the assignment video (as a sequence of scenes) reporting today's weather report, the river water level and the current situation in the area.

 1. Open Dam	 2. Evacuate	 3. Rescue
 4. Raise Metal Barriers	 5. Raise Sandbags Barriers	 6. Wait and See
 7. Close Tunnels/Bridges	 8. Cut off electricity & water	 9. Close metro lines

Table 2. Measurement decision.

problem is to generate the appropriate context awareness during the simulated fake crisis. An even bigger problem is to organize training sessions for citizens of Prague.

The developed MOOC offers digital training facilities for citizens of Prague and interested students. One of the provided options is to offer participants a role in the crisis management team and to play a simulated flooding crisis. This enables participants to experience the problems of crisis management and increases the sensitiveness for the crisis problems. The goal of this management team is to secure safety of citizens and to prevent/reduce damage of properties and infrastructures.

The flooding crisis game will be played as follows: every day the management team receives new information about the weather forecast, the water level and the current situation of the city. The information is coming in the form of an assignment video (**Figure 8**). After receiving the assignment video, the crisis management team has to select a measurement to be executed. Many measurements as displayed in **Table 2** interfere with each other. For example, after closing the transport facilities, it will be difficult to immigrate a great number of citizens. Whereas, before the dikes are breached and the water is increasing in the street, it is difficult to motivate people to immigrate. The participants have to imagine that there is an enormous time pressure while considering these actions. If the management team executes some measurements too late, it will be difficult to repair afterwards. On the other hand, if some areas are inundated on purpose to save other areas, this will not be appreciated by people living in inundated areas. One of the biggest problems is the probabilistic nature of a flooding disaster. After the management team makes a daily selection, the choice will be commented automatically. By playing the crisis game players, we expect that the participant will be confronted with many problems to solve. Consequently, their awareness of the complexity of a flooding crisis will increase by their involvement in the decision-making process.

4. Presentation, experiment and survey

4.1. Conference presentation

In 2016 a Smart City Symposium was organized in Prague. One of the topics was the design of information systems and surveillance systems to protect the city and its environment for disasters as flooding, landslides, and fires. A first prototype of the MOOC [26] on flood control was presented for an audience of scientists, representatives of the city council and representatives of first responders. It was appreciated that the MOOC was based on the flooding disaster in 2002. Participants were interested in the results of a large scale user test.

From 2013 to 2016 a European project ETN FETCH was running on development of Future Education and Training in Computing: How to support learning at anytime and anywhere with a focus on long-life leaning. More than 80 European Universities were partner in the project. One of the authors was a work package leader responsible for the development of new didactic models of distant learning with focus on MOOCs. On the yearly work package meetings and e-learning conferences the progress of the development of the MOOC on flooding disaster response was reported and discussed by a forum of 120 researchers specialized in distant learning. The results were reported in the proceedings of the e-learning conference [24–28]. The focus of the e-learning conferences was on the development of new didactical models, and high dropout rates of MOOCs. In the current paper the focus is on the training, increased awareness and training of cognitive models and abilities of citizens during flooding disasters.

4.2. Preliminary experiment of management role play game

At the start of the academic years 2016 and 2017, 483 first year's students of mathematics and computer science took part in the flooding game during their introduction time at Delft University of Technology. The game started with an introductory lecture of one of the authors on the flooding disaster in Prague in 2002. After the lecture, the students were split up in groups of 15 students. They were supposed to play the role of the crisis team during flooding and had to rank 7 measurements displayed in **Table 3** on a priority scale (with 1 being the least important measure to 7 being the most important measure).

Table 4 presents the average group score of the 7 measurements that was resulted in this experiment. Only prediction of the river water level had a high ranking which was not a big surprise for students of mathematics and computer science. The lower scores of the other measurements could be related to less preferred measurements to be executed at the onset of

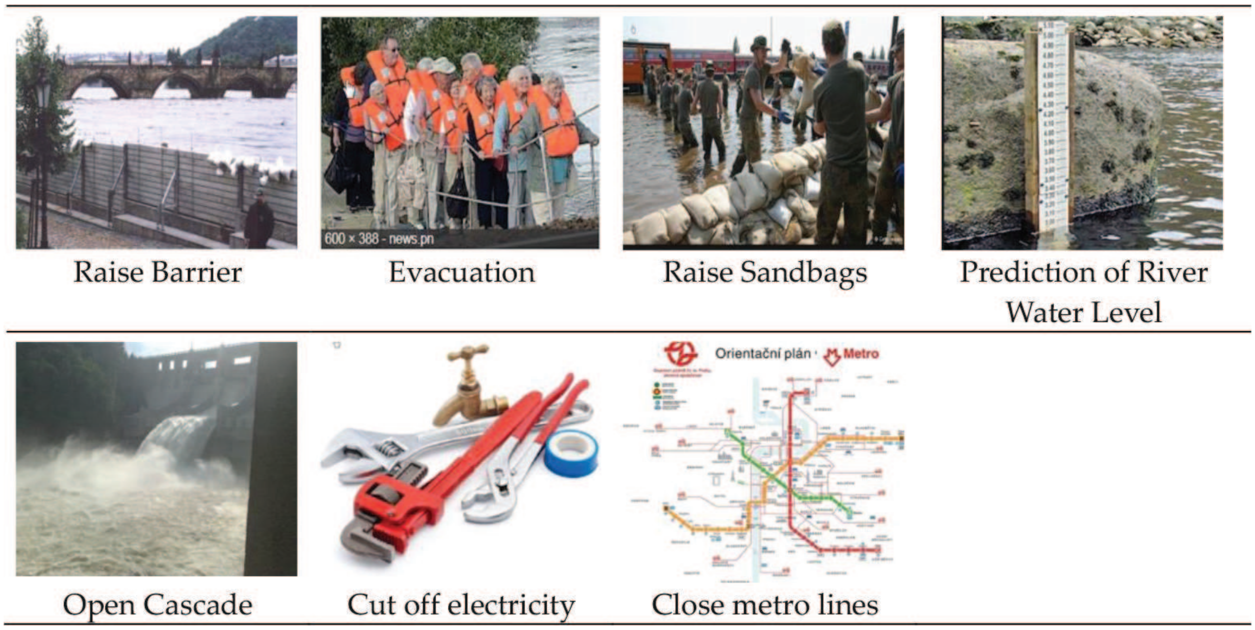

Table 3. Measurement decision in an experiment.

Barrier	Evacuation	Sandbags	Prediction	Cascade	Electricity	Metro
4.43	3.14	3.64	6.64	4.29	2.43	3.00

Table 4. Average score of priorities on a 10-point scale.

the flooding. Therefore, a lengthy discussion within the management team was needed to rank these measurements. The comment provided by the students showed that they were not aware of the heavy impact of mass evacuation and the speed and destructive power of the raising water.

4.3. Preliminary survey

To investigate the situation awareness of civilians of the different aspects of a flooding crisis, a survey was conducted involving 207 students of mathematics and computer science students at Delft University of Technology. In this survey, they were asked to fill in a questionnaire of 12 statements. The students could score on a 5-point scale if they agree or not with the statement with 1 being the completely disagree to 5 being completely agree. The results of the survey are presented in **Table 5**.

Based on the survey results, we found that most students were not aware of the complexity of a flooding disaster and the correlation between different components. However, these students had already made their own crisis plans and did not believe in the worst-case

Items/scale		Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
1.	I was not aware of the complexity of the flooding disaster	5	22	33	85	62
2.	I was not aware of the strong correlation between measurements	12	40	26	93	39
3.	The main unpredictable variable is the weather forecast	8	25	36	47	91
4.	In crisis situation, I follow my own plan	25	39	76	44	23
5.	In the past, it proves that crisis managers predict worse case scenarios	4	38	117	33	15
6.	It should be possible to rank the measurements on a priority scale	8	19	64	83	33
7.	Civilians wait for the very last moment before leaving the crisis area voluntary	6	21	38	87	55
8.	The behavior of the citizens is unpredictable	10	41	112	35	9
9.	It is difficult to implement the actions of the management team because of conflicting interests	24	30	37	97	29
10.	It was difficult to select measurements because of missing information and knowledge	6	31	33	103	32
11.	Every student has to take courses in crisis behavior at school	9	33	106	52	7
12.	It is a good idea to develop MOOCs for different types of crisis	14	51	87	44	11

Table 5. Average score list of priorities.

scenarios. Further, the analysis of the comments following the questionnaire showed that: Most students stress the fact of a planning and a disaster plan. There was also a request for computational model. Bayesian networks models could be used to predict the raising of the water. Mathematical models can also be used to describe the flooding of areas next to the river in case of breaching the dikes. The hilly terrain is full of peaks and valleys. Detailed maps are available and could be used how the water will be spread over the area using finite elements methods [18]. Students did not realize that most civilians use a subjective risk assessment instead of objective methods predicting the behavior of the whole cohort of people.

5. Conclusion

The goal of this paper was to improve awareness, cognition and abilities of civilians of flooding disasters by education delivered by MOOCs. Literature surveys and our preliminary results showed that MOOCs could be used to educate civilians. One of the advantages of MOOCs is that the educational material is easily accessible via MOOCs for a mass audience. Furthermore, no entrance exams or preliminary education is required. Unfortunately, our MOOC on flooding disaster response would also be subject to the disadvantages brought by MOOCs in general such as high dropout rates. However, regular training of first responders is usually compulsory. In such cases, the obligation of the first responder to use the MOOC can be a boost point for the participation rate. Furthermore, we received a great interest from authorities, involved in risk reduction in the Czech Republic, in the use of MOOCs for various risks, such as fires, landslides, traffic accidents, accidents in chemical complexes, and pipeline explosions. As a proof of concept, some MOOCs on disaster management have been developed in 2016, and published on the platforms *Coursera* and *edX*. These MOOCs were focused on the development of abilities of civilians and first responders to be used in crisis situations. We hope and expect that current MOOC will play a role in disaster education next future. To improve the awareness of civilians, the MOOC should be a regular course in the curriculum of students at Universities and secondary schools specifically at the areas that prone to flooding disaster. However, at the moment this is wishful thinking.

We mentioned already that by gamification, a MOOC can be attractive for many players. Inspired by the last summer of 2016's big hype around the game Pokémon Go, we observed that many players from different ages and educational background took part in the game. Players used their smart phone to catch virtual characters (Pokémon). An attractive aspect of the game was that players could meet each other on specific locations as squares, parks, beaches to exchange information and to play tournaments. As MOOCs are designed for participant's remote in place and time, we can apply such a game design for developing a new MOOC. When there is a need of the MOOC participants to meet each other for some days on a specific public domain location, the MOOC can provide a media for meeting, appointments and announcements. For example, in our case, the designers of the game could plan an event on one of the islands in the river Vltava in Prague during the summer and use the event to stress the game aspect of the MOOC as a serious game.

From the roleplay game experiment and the survey involving the university students, we found that missing information and knowledge was a problem for the participants to take the right decision and offering their opinion. It can be questioned if a sample of students is a good representative of civilians in a city. However, we consider the results of the experiment and the survey as a first promising step. As the experiment and the survey was taken before the participants followed the MOOC, it will be interesting to see if the opinions will change the coming years after following the MOOC. Future work will include first responders and members of the city council in the survey. At this moment, the MOOC is tested on a large scale of audience and new results will come available in the coming year.

Learning on the preliminary results, therefore, in the roleplay game of the current MOOC, we designed that students would be confronted with the weather forecast and level of the raising water on a daily basis and have to select a measurement. We expect that such information will provide more time pressure and raising actions in the game especially when the flooding conditions are changing dynamically. Furthermore, we also observe that a greater part of civilians takes apart in MOOC education, such as managers, which are also a target population of our research. From the massive character of MOOCs in general, we can expect that MOOCs will play an important role in the education of civilians on disasters. Finally, although we tested only one module of our MOOC, that is, the management game, however, other learning modules of the MOOC have covered the different aspects of flooding. We expect this will also increase the awareness of civilians of flooding.

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