Designing a flood-risk education program in the Netherlands
Abstract

This study focused on designing a flood-risk education program that aimed for enhancing 15-year-old students’ flood risk perception and preparedness intentions. The design process was guided by the principles of Educational Design Research and had an iterative character. The design of the program was based on theoretical understandings from learning theory, information processing and risk communication. Furthermore, empirical findings about students’ risk perceptions were incorporated. During the development of the program, the intermediate products were evaluated formatively by geography teachers, focusing on the consistency, practicality and effectiveness of the program. Simultaneously, design principles, which are theoretical notions that are typical for the design of the contents and pedagogy of the program, were determined. Affect, availability and blended learning were determined as guiding design principles. In the flood-risk education program, learning processes were modeled in such a way that the arousal of moderate levels of fear should prompt experiential and analytical information processing. In this way, understanding of flood risk in the surroundings should prompt students’ threat and coping appraisal. To accomplish this, the program consisted of a variety of student-directed parts like serious games and flood simulations.

Key words:
- flood-risk perception
- belief change
- information processing
- blended learning
4.1 Introduction

Although the Netherlands is well known for its low elevations and zealous efforts to protect the country against flooding, the Dutch population is hardly aware that flooding still is a threat that has to be reckoned with. For many people flooding belongs to the past because they assume that authorities have done everything they can to protect the country, as if safety could be guaranteed. Although people in the Netherlands live in a country with dikes and barriers combined with an age-old flood history, flood risk is not salient at all, let alone that thinking of flooding would evoke fear. This conception is deeply embedded in society and Heems and Kothuis (2012) call this "the myth of dry feat". Previous studies (Bosschaart et al., 2013; Bosschaart, Kuiper, & van der Schee, 2015) showed that this myth is also applicable to Dutch students. Within this framework education and communication about this risk is a challenging task.

This study covers the role formal secondary education, i.e. geography education, can play in achieving or facilitating the goals of flood-risk communication in the Netherlands. Until now, the opportunities of formal education with respect to flood-risk communication are hardly acknowledged. This is remarkable because education can be more powerful than communication campaigns and formal education influences the future generation. Moreover, flood-risk communication deals with information that is to a large extent geographical in nature. Consequently, it seems obvious that geography as a compulsory subject in the first three years of secondary education in the Netherlands should play an important role on this topic.

Therefore, this study aims at designing a flood-risk education program that contributes to raising students' flood-risk perceptions and their preparedness intentions. The main task of this program will be to deconstruct "the myth of dry feet" (Heems & Kothuis, 2012). Lindell and Perry (2004) put this into more tangible words:

"The purpose of hazard communications is to prompt people to redefine the situation from one in which the environment is primarily positive to one in which the environment is threatening. The process of redefining the situation leads to the identification of possible actions that could be taken and concludes with decisions about appropriate responses to the threat."

Until now, risk communication as well geography education with respect to flood risk paid attention to the Netherlands in general (Bosschaart et al., 2013). There are various reasons to tune a flood risk program on the regional situation. First
of all, the flood-prone areas in the Netherlands differ enormously with respect to elevation, flood mechanism, flood protection and vulnerability and hence in necessary protective action. Besides, previous studies have shown that students in the Netherlands are well aware of flood risk in the Netherlands in general. But the optimistic bias is applicable to flood risk perception concerning their own surroundings (Bosschaart et al., 2013). Therefore, the program to be developed, was tuned to a particular location of schools in a flood-prone area in the Netherlands: West-Friesland, a region in the province of North-Holland. The program was designed with the characteristics of this region in mind and making use of information of the regional water board, the authorities that are responsible for water safety.

Because the design of a flood-risk education program is complex and challenging, we have based the design process on the principles of Educational Design Research (EDR). According to Plomp and Nieveen (2009) systematic study of designing, developing, and evaluating an educational intervention is necessary in order to be successful.

### 4.2 Method and aims

The main research question of this study is: *What are the characteristics of a flood-risk education program in the Netherlands that contributes to improving 15-year-old students' personal flood-risk perceptions and flood-preparedness intentions?* In developing a flood-risk education program or product, we have reasoned from the key principles of Educational Design Research (Plomp & Nieveen, 2009; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). This type of research can be characterized as interventionist, iterative, involvement of practitioners, process-oriented, utility-oriented and theory-oriented. This means that next to the practical aim of an effective flood-risk education program, this study focuses on finding valid design principles as the scientific yield of this type of research. Design principles are preliminary assumptions that represent the essential functions and characteristics of the program to be developed. These 'substantive' principles are also called 'heuristic statements' or 'intervention theory' (Wademan, 2005).

Figure 4.1 shows the way the main research question has been elaborated into seven more specific research questions, as well as the iterative character of the design process. During each stage the product of the prior stage has been evaluated formatively on the basis of the specific research question. During focus group discussions seven geography teachers and four geography teacher-trainers evalu-
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<td>5</td>
<td>Definitive product (teaching and learning material)</td>
<td>Results and evaluation by geography teachers (7)</td>
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**Figure 4.1** Overview of the design research process.
ated the product. With respect to the research questions 3, 4 and 5 the participants
gave their comments individually by using the format of a SWOT-analysis after
which a group discussion took place. The participating geography teachers came
from schools that are located in the area for which the flood-risk education program
was developed and from schools in flood-prone areas in the same province.

The first stage consisted of an analysis of theoretical understandings and em-
pirical findings. This resulted in a set of tentative design principles and a global
design of the program. The global design consisted of a general description of the
aims, pedagogy and contents of the flood-risk education program and the role of
teacher and students. The development of the flood risk education program took
place during the stages 2, 3 and 4. Stage 2 consisted of evaluating the global
design. This resulted in adapting the design principles and pedagogical approach
and elaborating the content of the program. During the third and fourth stages the
flood-risk education program, consisting of teaching and learning material, was
evaluated and adapted. The fifth stage about the actual effectiveness of the pro-
gram will be reported in a separate study.

4.3 Analysis

The main aim of the flood-risk education program is raising awareness and
strengthening risk perception and preparedness intentions. Therefore we based
the design on empirical findings about the way Dutch students perceive flood risk
as well as theoretical understandings concerning learning theory, information pro-
cessing and risk communication.

4.3.1 Students' perceptions and mental models with respect to flood risk in
the Netherlands

Previous studies (Bosschaart et al., 2013; Bosschaart et al., 2015) made clear that
although Dutch students know there is a flood-risk in the Netherlands in general,
they hardly apply this to their own situation. Students' personal flood-risk percep-
tion is low and they hardly perceive fear when thinking about flood risk. Further-
more, students' trust in water safety is high and their level of knowledge about
flooding in the surroundings is low. Regression analysis made clear that students'?
flood risk perception is influenced positively by fear and knowledge. Furthermore,
it has been found that flood risk is not at all salient, even when prompting students
with images of dikes and rivers at familiar spots in the surroundings. This makes clear that elements related to the river and flood-protection are not associated with thoughts about flood risk, let alone flood-related feelings. Therefore we may conclude that both the affect heuristic and the availability heuristic, that function as "mental shortcuts" (Slovic et al., 2004), are applicable to students' flood-risk perception in the Netherlands. This implies that intuitive feelings and (the lack of) experienced events largely determine students' perceptions.

According to Bostrom et al. (1992) and McClure, Walkey, and Allen (1999) the extent to which mental models are sophisticated, determines risk perceptions. Students' mental models in two Dutch cities in flood-prone areas, turned out to be fragmentary and consisted mainly of factual or declarative knowledge (Bosschaart et al., 2015). Structural knowledge, consisting of understandings about the where and why of flooding and its effects, is lacking largely. Visuospatial representations of height differences in the surroundings, which play an important role in understanding the inundation and inundation depths, are lacking. This also applies to mental simulations of the processes connected with dike bursts and flooding. Based on the aforementioned, it is not surprising that students possess fundamental misconceptions with respect to flooding and its consequences and that the way they reason about flooding is based on analogies and heuristics. Because of a high degree of ignorance with respect to prevention and disaster response, students' trust in water safety can be characterized as blind faith.

4.3.2 Learning theory

According to Illeris (2007) various learning theories emphasize different aspects of learning. Therefore, many learning theories are more or less one-sided. Illeris has tried to combine these existing theories into his model of the "three dimensions of learning", consisting of the cognitive, emotional and social dimensions of learning. With respect to internal learning, Illeris distinguishes a cognitive and an emotional dimension. Besides a psychological or internal process, social interaction is needed for learning to take place. Based on the work of Piaget and Kolb, Illeris distinguishes two learning processes: assimilation and accommodation. Assimilation is the type of learning whereby knowledge is added to the existing mental schemes, and accommodation takes place when the existing schemes do not correspond to the presented knowledge. In the latter case students have to reconstruct the existing schemes. Compared to assimilative learning, accommodative learning is more demanding and challenging and more mental energy is needed. Therefore, there
is a tendency to avoid this type of learning unless people are convinced to do so. Accommodative learning is facilitated when teaching methods are problem-oriented and students can co-determine the direction of what is to take place and teachers have a more or less supportive role. According to Illeris, cognitive and emotional processes intertwine, especially with respect to attitudes. Emotions affect interpretations and interpretations prompt emotions. It is said that positive emotions intensify existing knowledge structures through assimilative learning while negative emotions prompt problem solving through accommodative learning.

The constructivist approach to learning, which is also applicable to Illeris’ model, makes clear that knowledge is individually constructed and therefore fundamentally subjective. Knowledge construction takes place by building on existing knowledge. Therefore it is important for the teacher and the student to know to what extent the existing knowledge consists of misconceptions. Otherwise, these misconceptions operate as a barrier to successful learning. The social dimension in Illeris’ model builds on the ideas of Piaget and Vygotsky. Vygotsky has stated that mental operations have a social-communicative origin and thinking is restructured when it is expressed into language. Because mental concepts arise in the dialogue between children and adults, but also among children, verbalizing plays an important role. In order to put Illeris’ model into practice, we assume that learning should be blended.

4.3.3 Information processing

In social and cognitive psychology various dual process models are used to describe the way information processing takes place (Smith & DeCoster, 2000). Under normal circumstances people process information heuristically or associatively by using simple rules of thumb and making quick evaluations based on spontaneous associations, experiences and intuition. When the situation or the information causes more arousal and makes you feel threatened, the information will be processed systematically or analytically. This mode of information processing can be characterized as deliberate, analytical and effortful, and will only take place when there is enough time and cognitive capacity.

According to the Elaboration Likelihood Model (Petty & Cacioppo, 1986) and the Heuristic-Systematic information processing model (Chaiken, 1987) the chance that communication will lead to persuasion and enduring attitude change is enhanced when information is processed systematically. Motivation and the ability
to comprehend are a prerequisite for this mode of information processing to take place. Heuristic processing would lead to bias and to not more than temporary attitude change. On the other hand, Smith and DeCoste (2000) make clear that there are also dual-process models that state that both modes of information processing are necessary in order to process the information successfully. Finucane et al. (2003) described this as the "dance of affect and reason" and Slovic et al. (2004, p.314) add to this that "it is unlikely that we can employ analytic thinking rationally without guidance of affect somewhere along the line." With respect to decisions under uncertainty, associations, experiences and affect are considered to be necessary, while relying exclusively on heuristics and intuition should be avoided. According to Visschers and Meertens (2008) the first spontaneous reaction to a risk is affective and has to do with gut feeling and prior experience. Also Zajonc (1980) has emphasized the affective primacy. And this inescapable affective reaction influences the nature of the continuation of information processing. Besides, Loewenstein et al. (2001) made clear that affective response could also be the result of cognitive evaluations.

4.3.4 Risk communication

With respect to risk communication many authors have emphasized the importance of incorporating the two modes of information processing (Marx, Weber, Orlove, Leiserowitz, Krantz, Roncoli, & Philips, 2007; Visschers & Meertens, 2008; Zaalberg, Midden, Meijnders, & McCalley, 2009). Possibly the most apparent advocates of this approach are Slovic et al. (2004). Building on the work of Damasio (1994) and Epstein (1994), they state that the 'complex interplay of emotion, affect and reason' is essential to rational behavior.

In situations where people do not have experience with a hazard and the probability of the hazard is low, cues from the environment are mostly reassuring. Then, risk communication or risk education is the only way to influence people's risk perceptions. The Protective Action Decision Model (PADM; Lindell & Perry, 2004) describes the way people decide about protective actions as a stepwise process. This process starts with the reception of, attention to and comprehension of information. These so-called pre-decisional processes determine subsequently people's threat appraisal, their assessment of the personal relevance and the assessment of potential coping behavior. In order to design successful risk communication, Lindell and Perry have stressed the importance of taking into account all these subsequent steps.
When people are confronted with information that is contradictory to their existing knowledge, they often try to find a justification for their existing beliefs (Lindell & Perry, 2004). This is called the confirmation bias. Then, the intrusiveness of the information determines the way people are inclined to process the information and adapt their beliefs. Within this framework Lazarus (1988) made clear that when information processing has no connection with personal stakes, "knowledge is cold cognition".

According to the Protection Motivation Theory (PMT; Rogers, 1983) the arousal of fear could stimulate cognitive evaluation of the threat and the response. However, Ruiter, Abraham, and Kok (2001) made clear that fear appeal could also have inhibiting effects on protection motivation. When the level of fear is too high the cognitive response could lead to ignoring or denial of the threat. This type of response is called 'emotion-focused coping'. 'Problem-focused coping', the strategy to reduce the physical threat or vulnerability, is the adaptive response where risk communication is aiming for. Based on the PMT, Bubeck, Botzen and Aerts (2012) made clear that people’s preparedness intentions are not only influenced by their threat belief or risk perception. Preparedness intentions are also influenced by the people’s coping appraisal which can be described as the way people perceive the efficacy and costs of flood-preparedness measures as well as their self-efficacy.

Various authors have emphasized the effect of previous experience with flood hazards on risk perception (Grothmann & Reusswig, 2006; Siegrist & Gutscher, 2006; Terpstra, Lindell, & Gutteling, 2009). In case people have no experience with a hazard because of the low frequency of occurrence, risk communication could focus on producing vicarious experiences through experimental manipulation. A traditional way is the use of fear-evoking images. In an experimental study Terpstra et al. (2009) found modest results. Zaalberg et al. (2009) suggested the use of 3D-technology in order to mimic a disaster experience that is experienced as "real". A high-end virtual environment should not only produce bodily experiences but also emotional arousal. In the aforementioned, risk perception has been described as an internal construction. On the other hand Joffe (2003) has emphasized that the formation of people’s beliefs with respect to risks is guided by ideas and judgments that are predominant within related groups:

"Explanations and judgments are not constructed within individual minds but in the ‘unceasing babble’, the ‘permanent dialogue’ that people have with each other and with institutions." (Joffe, 2003; p.68).
Breakwell (2001) has called this the ‘subcultural base for any individual’s mental model’. In Rohrman’s risk communication model (Rohrman, 2000) the societal discourse plays an important role.

4.4 Outcomes of the design process

4.4.1 Underpinning of the flood-risk education program

In order to design a flood-risk education program that contributes to belief change with respect to flood-risk perception and preparedness intentions, it is necessary to consider the way people think and judge about this topic as a stepwise process: (1) extending knowledge and understanding about flood risk; (2) raising awareness and strengthening personal flood-risk perception; and (3) influencing preparedness intentions (Figure 4.2). It has to be emphasized that the cognitions concerning the first step differ from those with respect to step 2 and step 3. While the first step focuses on information processing that should lead to knowledge about the way things are and how they work, step 2 and 3 deal with the appraisal or evaluation of that knowledge in relation to personal well-being.

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<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td><strong>Sequence</strong></td>
<td>Knowledge and understanding about flooding and hazard adjustments</td>
<td>Flood-risk awareness and flood-risk perception (Threat appraisal)</td>
<td>Flood-preparedness intentions (Coping appraisal)</td>
</tr>
<tr>
<td><strong>Obstacles</strong></td>
<td>Conceivability Misconceptions Confirmation bias</td>
<td>Optimistic bias</td>
<td>Denial (Emotion-focused coping)</td>
</tr>
</tbody>
</table>

Figure 4.2 Thinking of flood-risk as stepwise process.

Figure 4.2 shows the sequence of steps as well as the obstacles that are applicable to that step. We assume that presenting information not automatically leads to knowledge and understanding. Furthermore, knowledge and understanding do not automatically lead to awareness and personal risk perception. Finally, risk perception does not automatically lead to preparedness intentions. In order to overcome
these obstacles, we assume that a combination of both analytical and experiential information processing has to be initiated in such a way that both assimilative and accommodative learning can take place. In the stepwise process, analytical and experiential information processing are intertwined and are a requisite for proceeding the sequence. This means that we assume that the conscious analysis of information (step 1) will be initiated by intrusive information about flooding, like virtual dike breaches and flood simulations. The analysis of intrusive information, which will enhance knowledge and understanding about flooding in the surroundings, should in turn evoke affective reactions that motivate students to appraise the threat of flooding and the coping possibilities. The challenge lies in selecting and presenting information in such a way that moderate levels of fear are evoked. It has to be emphasized that the stepwise process is not necessarily linear. Following Lazarus and Smith (1988), we assume that knowledge and appraisal, although different kinds of cognition, could function simultaneously.

In the course of the research process the design principles evolved and were sharpened. Initially, we thought that the essential functions and characteristics of the program could best be described with the principles motivation, systematic processing and interaction with the surroundings. This stemmed from empirical understandings and the first reading of the literature. In hindsight, after evaluating the substantive part of the design process, we assume that the design principles are affect, availability and blended learning. Affect can be described as feelings of 'goodness' or 'badness' which are tagged to mental images (Slovic et al., 2004). These feelings influence information processing and the perception of risk. Availability has to do with the salience, conceivability and understanding of flood risk. With blended learning, we mean a variety of pedagogical methods. Because learning that contributes to both knowledge and understanding as well as belief change, is the result of learning activities that should prompt the two modes of information processing, all three dimensions of learning (Illeris, 2007) should be dealt with.

4.4.2 Flood-risk education program

The flood-risk education program\(^3\) consists of teaching and learning material that is tuned to 15-year-old students at pre-university education level (VWO) and senior general education level (HAVO).

*Pedagogy*

\(^3\) The flood-risk education program is available on www.vakdidactiekaardrijskunde.nl
The pedagogical approach aims at evoking both experiential and analytical information processing. Therefore a variety of learning activities or mental processes is needed that facilitates both types of information processing (Figure 4.3). These learning activities are combined within the student-directed parts and reinforce each other. During the first four lessons teacher-directed learning parts are alternated with student-directed parts. The last three lessons consist of inquiry-based group projects that are largely student-directed.

<table>
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<tr>
<th>Learning activities</th>
<th>Experiential processing</th>
<th>Analytical processing</th>
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<tbody>
<tr>
<td>- experiencing</td>
<td>- analyzing</td>
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<tr>
<td>- making associations</td>
<td>- verbalizing</td>
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<td>- tagging with feelings</td>
<td>- reflecting</td>
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<td>- field experience</td>
<td>- field observations</td>
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<tr>
<td>- reacting</td>
<td>- making mental simulations</td>
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<tr>
<td>- trial and error</td>
<td>- constructing images of geographical space</td>
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**Figure 4.3** The design principles elaborated.

**Contents**

The contents of the program have been adapted to the regional and local setting of the participating schools. The threat of flooding has been elaborated as a chain of successive events that take place prior to and during a flood (Figure 4.4: lesson 1,2,3):

- high water levels > dike breaches > flooding water > effects for inhabitants

We assume that understanding flood risk depends on different types of mental representations. First of all, mental representations of water levels and the land sur-
### Chapter 4

#### Flood-risk education program with respect to West-Friesland

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<th>Contents per lesson</th>
<th>Student directed parts</th>
<th>Teacher / student direction</th>
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<td>Dikes and dike breaches in the province of North-Holland and West-Friesland</td>
<td>Causes (high water + dike failure mechanisms)</td>
</tr>
<tr>
<td>2</td>
<td>The effects of flooding in the province in West-Friesland</td>
<td>Effects (inundation area and depth + casualties + costs)</td>
</tr>
<tr>
<td>3</td>
<td>Water management in the province of North-Holland</td>
<td>Authorities (prevention, mitigation, disaster preparedness)</td>
</tr>
<tr>
<td>4</td>
<td>Flood preparedness and mitigation measures in the surroundings</td>
<td>Self (prevention, mitigation, disaster preparedness)</td>
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<td>5</td>
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</table>

| Duration | 7 lessons of 50 minutes |

**Figure 4.4** Overview of the flood-risk education program.

face on both sides of the dike, as well as height differences in geographic spaces that are too large to perceive at once, have to be combined. Therefore field observations combined with mental maps are necessary. Besides, imagining low probability events with higher water levels and stronger winds than usual, is a requisite. Moreover, tagging historical flood information to local situations around dikes is needed. Finally, dike failure mechanisms that are presented on a draft, have to be tagged to dikes in the surroundings in order to elicit mental simulations of dike breaches. We suppose that virtual flood simulations tailored to the local situation as well as dike breaches in a 3D-setting may contribute to this understanding.

In order to prevent students from emotion-focused coping by emphasizing unilaterally the threats and effects of flooding, an important part of the contents is related to hazard adjustments (Figure 4.4: lesson 4,5,6, and 7). These adjustments deal with measures concerning prevention, mitigation and emergency preparedness, by the water boards and the inhabitants themselves. For the inhabitants it is necessary to know what they can expect from the water board with respect to prevention and emergency measures in order to appraise their own coping response.
Student-directed parts

- Serious game and flood-simulation
  Serious games and interactive simulations offer the opportunity to prompt both experiential and analytical information processing. Squire and Jenkins (2003, p.8) made clear that 'games are imaginary worlds, hypothetical spaces where players can test ideas and experience their consequences.' In this way games and simulations stimulate imagination and curiosity. But above all, the two modes of information processing are involved. According to Taatgen (1999) people can use two different learning strategies when playing a game. The experiential or search strategy is characterized by looking for cues in the digital environment, reacting on feedback and trial and error. This will result in intuitive knowledge which people find difficult to verbalize. As soon as the search strategy fails, the reflective strategy will be used. This strategy is about analyzing, comprehending and memorizing consciously and takes more time and is much more demanding. Squire and Jenkins (2003) argued that learning occurs when the game or simulation is alternated with other activities. Furthermore, they state that challenging games urge people to discuss the strategies with others which is an important aspect in reflecting on the learning itself.

- 3-D game Levee Patroller
  In the 3D-game Levee Patroller (Figure 4.4, lesson 1), students had to put themselves in the role of a levee patroller. In a virtual environment, students had to look for various types of weak spots in the dike during a period of high water. The weak spots had to be classified according to a list of dike failure mechanisms. In case they performed the task insufficient, a virtual dike breach occurred. Playing this game will increase students' involvement and makes dike failure conceivable.

- 2-D flood simulation
  Based on information of the regional water board, an interactive digital flood simulation that was useful for students (Figure 4.4, lesson 2) was developed by the first author. This simulation had a regional map of the school surroundings as a starting point and enables students to create dike breaches at various spots along the dikes in their own surroundings. Subsequently, the effects of the particular dike breach (inundation area, inundation depth, casualties and costs) are shown and students have to analyze the effects.
- Societal discourse
By giving students the task to question their relatives and friends about flood risk perception and preparedness (Figure 4.4, lesson 3), we intended to create a situation in which they get into conversation. In this way students will be urged to verbalize and explain what they have experienced already. This societal discourse is very important in the shaping of their opinion and beliefs.

- Fieldwork
The fieldwork assignment (Figure 4.4, lesson 4) consists of closed-ended observations of a small part of a dike in the surroundings. By observing the dike and encouraging students to assess the strength of the dike on site, we assume that students are in the position to tag the elements like dikes, ditches and water levels with flood related images and mental simulations which they experienced during the lessons prior to the fieldwork. These associations between experiences, elements in the surroundings and flood risk, should make it possible to pick up from memory flood related and affect-laden images more easily. Hereby the information would get personal relevance and would become conceivable.

- Group-project
In contrast to the fieldwork assignment that has a closed style, the group-projects are more open. The group-projects (Figure 4.4, lessons 5, 6 and 7) are problem-oriented around hazard adjustments by water boards and the people themselves. Students can choose different projects of which the enquiry questions are fixed. The way students gather the information and make a presentation is more or less open-ended and the students are encouraged to describe their opinion and beliefs about the various topics. In this way students are involved in the topic which becomes more meaningful to them.

4.4.3 Description of the design process and the design principles

In this section we describe the way the authors used the iterations or stages to evaluate the design principles as well as the manner in which the participants’ evaluations of the intermediate products were used. In the course of the successive stages of the design process, the authors questioned what design principles best described the functions and characteristics of the flood-risk education program (research question 2). The first set of three design principles, *motivation*, *systematic processing*, *interaction with the surroundings*, originated from stage 1. During the stages 2, 3 and 4 the tentative design principles evolved and were
sharpened. In hindsight, after an iterative process as described in the stages 1 to 4, we conclude that a program that aims at changing flood-risk perceptions and preparedness intentions, should start with intrusive information and extending knowledge and understanding. By evoking both experiential and analytical information processing, the appraisal of the threat of flooding and the coping strategies will be initiated. This could lead to belief change. Therefore, the functions and characteristics of the flood-risk education program could best be described with the design principles *affect, availability, and blended learning*, as described in section 4.4.1.

The design process consisted of five stages. During the stages 2, 3 and 4 the design products of the preceding stage were evaluated by experts in a focus-group discussion. In this study the first four stages of the process are described starting from the research questions presented in Figure 4.1. The development of the global design and the first and second draft of the teaching and learning material, took place during stages 2, 3 and 4. Stage 2 focused on the soundness of the design ideas and coincides with the phase of ‘alpha testing’ as described by McKenney and Reeves (2012). Stage 3 and 4 had to do with the viability of the teaching and learning material. These stages coincide with the phase of ‘beta testing’ (McKenney & Reeves, 2012).

The participants’ comments are categorized in a SWOT-format as listed in Figure 4.5. The consistency of the curricular components (research question 3), the variety of pedagogical methods, the problem-oriented character and the 2D-simulation were judged positively. Suggestions were made about a more prominent role of affect and the more student-directed parts concerning coping strategies. This was taken up in the first draft of the teaching material. The expected practicality and effectiveness of the teaching material (research question 4) were studied during stage 3. Core issues of geography teachers’ comments are listed in Figure 4.5. In general, geography teachers assessed the material as inspiring and stimulating because of the pedagogical variety, the use of a 3D-game and 2D-flood simulation and the focus on the surroundings. Their main concerns had to do with the explicitness of the 2D-flood simulation, the possibility for students to reflect and the feasibility with respect to required time. These comments were taken up in the second draft.

Stage 4 consisted of a try-out. Two geography teachers used the teaching material during their lessons with two groups of 15-year-old students at pre-university education level (VWO) and senior general secondary level (HAVO). The teachers
<table>
<thead>
<tr>
<th>Stages of the design process</th>
<th>Research questions</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global design</td>
<td>3 What is the internal consistency of the curricular components</td>
<td>Evaluation by geography teachers (5) geography educationists (4)</td>
</tr>
<tr>
<td>Adaptations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First draft of teaching material</td>
<td>4 What are the expected practicality and the expected effectiveness of the teaching material?</td>
<td>Evaluation by geography teachers (7)</td>
</tr>
<tr>
<td>Adaptations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second draft of teaching material</td>
<td>5 What is the actual practicality of the teaching material?</td>
<td>Evaluation by geography teachers (2)</td>
</tr>
<tr>
<td>Definitive product (teaching material)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Designing a flood-risk education program in the Netherlands

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>- the way 2D-simulation is interwoven in the curriculum</td>
<td>- not enough attention to affective goals</td>
<td>- start with evoking affect-the-way knowledge could influence attitudes</td>
<td>- the possibility to adapt the professional flood simulation into a 2D-flood simulation that is usable for students</td>
</tr>
<tr>
<td>- alternation of pedagogical methods</td>
<td>- too little account of differences between teacher- and student-directed learning activities</td>
<td>- students could make their own evacuation plan</td>
<td></td>
</tr>
<tr>
<td>- the contents is problem-oriented</td>
<td></td>
<td>- timing of fieldwork</td>
<td></td>
</tr>
</tbody>
</table>

> 3D-game was added to the first lesson  
> 5 different group projects with respect to preparedness and damage mitigation were added (students chose one)  
> fieldwork was removed to a later stage

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>- challenging textbook with assignments</td>
<td>- instruction 2D-simulation is unclear</td>
<td>- reflection on the outcomes of the various parts</td>
<td>- it could be difficult to get students into conversation with relatives</td>
</tr>
<tr>
<td>- 3D-game and 2D-simulations are very motivating</td>
<td>- not enough attention to reflection at the end of each part</td>
<td></td>
<td>- feasibility within time</td>
</tr>
<tr>
<td>- awareness raising is possible because of variety in pedagogical methods and problem oriented approach that focuses on the surroundings</td>
<td>- content too extensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- instructions in some group projects are too vague</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> instruction of 2D-simulation were adapted  
> teacher guidelines with respect to discussing the outcomes of the 2D-simulation were adapted  
> instructions group projects were adapted  
> reflection tasks at the end of various parts were added

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>- students are challenged by 3D-game and 2D-simulation</td>
<td>- instruction 2D-simulation unclear</td>
<td>- starting with fieldwork could be more motivating</td>
<td>- lessons of 50 minutes are not long enough</td>
</tr>
<tr>
<td>- the school surroundings motivate students</td>
<td>- discussion time simulation is too short</td>
<td></td>
<td>- students' motivation with respect to fieldwork</td>
</tr>
<tr>
<td>- a good balance between fear arousal and coping</td>
<td>- there is differentiation between both levels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> teacher guidelines with respect to instructions of 2D-simulation were adapted  
> teacher guidelines with respect to planning fieldwork were included  
> extra lesson was taken up in the schedule

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**Figure 4.5** SWOT analyses in relation to research questions 3, 4, and 5.
prior to the 2D-flood simulation and the time for reflection afterwards. Besides, the
motivation for the fieldwork assignment was less than expected. This had mainly to
do with obligations of other school-subjects at the same time. This makes clear that
tuning to the school-organization plays an important role while carrying out such an
intervention with pedagogical methods that partly take place as homework.

4.5 Conclusions

This study reports on the development and formative evaluation of a flood-risk
education program in the Netherlands, based on an educational design research
approach. The objective of this study lies in describing both the design product
and design process. Furthermore, this study aims for design principles, theoretical
notions about the functions and characteristics of the program that evolve during
the design process.

The challenge of this study lies in designing a flood-risk education program that
contributes to improving 15-year-old students' personal flood-risk perceptions and
flood-preparedness intentions. Based on risk communication research we assume
that students' thinking about flood risk should be modeled as a stepwise process
that consists of knowledge and understanding, awareness and perception, and
preparedness intentions. In order to overcome various obstacles in this stepwise
process, we have made use of learning theory and understandings about informa-
tion processing that proved to be complementary. Learning processes have to be
modeled in such a way that accommodative learning will take place. This can be
achieved when learning activities consist of both experiential and analytical infor-
mation processing.

In the flood-risk education program students are confronted with intrusive flood-
risk information about the local situation that should arouse moderate levels of
fear. In this way, students are prompted to process flood-risk information analyti-
cally, without causing panic and emotion-focused coping. By incorporating serious
games, simulations, fieldwork and discourse, students should experience different
aspects of flood risk in the surroundings. This enables students to tag elements in
surroundings with flood risk information and affect-laden imagery. By emphasizing
both the threat of flooding and coping measures students should get a balanced
picture of flood risk.
During the development of the flood-risk education program that consists of teaching and learning material, experts evaluated the intermediate products formatively. Consistency, practicality and expected effectiveness were evaluated successively. Although experts evaluated the alternation of pedagogical methods and flood-risk related topics positively, they were critical about achieving the affective goals. Therefore reflection assignments and group-projects were incorporated. Finally, the try-out showed that geography teachers were convinced that exposing students to intrusive information, in combination with attention to coping strategies, could bring about belief change without causing panic.

In the course of the development of the flood-risk education program, the design principles affect, availability and blended learning evolved. For the time being, we assume these principles are the main characteristics of this program that should contribute to realistic flood-risk perceptions as well as preparedness intentions. As soon as the intervention has taken place, it will be clear whether these principles will last.

Limitations
The main research question of this study is about determining the characteristics of a flood-risk education program that contributes to improving flood-risk perceptions 15-year-old students in flood-prone areas. Within this framework, we have to take into account the limitations of this study. These limitations have to do with the position of the flood-risk education program in the geography curriculum and with the character of this study. Both Heems and Kothuis (2012) and Harries (2008) made clear that risk perceptions and attitudes towards preparedness are deeply embedded in more fundamental beliefs that are prevalent in society. Perceptions and attitudes should be influenced by notions about the relation man-nature, the manipulability of the environment and the distribution of responsibilities in society. In order to change these fundamental notions, it might be possible that a flood-risk education program of 7 lessons would be too short. Possibly more fundamental changes in the geography curriculum of junior secondary education are necessary.

As this study focuses on the design process of the flood-risk education program, an experiment with the program is not part of this study. In order to judge the effectiveness of the program, it is necessary to test the flood-risk education program experimentally in schools in the targeted area. This will be the only way to determine the effect of the flood-risk education program on beliefs with respect to flood risk.
“Yes, absolutely if you are there where the dike bursts. In Geldermalsen it won’t be that bad.”