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Dry feet in the polder? Improving flood-risk perception of 15-year-old students in the Netherlands

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Conclusions, discussion and implications



6.1 Introduction

This thesis focuses on the way geography education could play a role in raising flood risk awareness among 15-year-old students in the Netherlands. The main aim was to develop and evaluate a flood-risk education program that contributes to enhancing flood-risk perception as well as preparedness intentions. Prior to the design and development of the flood-risk education program, the studies reported in chapter 2 and 3 aimed at scrutinizing students' thinking about flood risk. Besides determining students' perceptions, their levels of knowledge and mental models, these studies aimed at explaining these perceptions and mental models. The first two studies formed the basis for the design and development of a flood-risk education program in chapter 4. In the design process theoretical understandings from learning theory, information processing and risk communication were incorporated. The design process was guided by the principles of educational design research. Finally, the flood-risk education program was evaluated via an experiment (chapter 5).

In this final chapter, conclusions are drawn by answering the research questions. In addition, the outcomes are discussed and reflected upon. Furthermore, implications are presented. Firstly, these implications deal with the elaboration of the existing geography curriculum in lower secondary education in order to incorporate flood risk in the Netherlands. Secondly, some fundamental and practical aspects of students' flood-risk perception require further research. Finally, this thesis brought to light some aspects concerning the use and nature of misconceptions as part of pedagogical content knowledge.

6.2 Conclusions and discussion

Before answering the main research question, the four more operational sub-questions will be answered and discussed.

***How do 15-year-old students in flood-prone areas in the Netherlands perceive flood risk and think about flood preparedness?
(Sub-question 1)***

The analysis of the survey among 483 15-year-old students (chapter 2) has shown that students' perception of personal flood exposure is low, while their general flood risk perception is moderate. Furthermore, students' perception of flood

consequences is moderate. In addition, students' perceived fear is low, their trust in water safety is high and students' perception of environmental cues is low. Students' knowledge about flood risk, based on a test with closed-ended questions, is low. These results have influenced the set-up of the interviews with students (chapter 3) by focusing on the surroundings of the school as well as the origins of high trust in water safety.

The analysis of the interviews with fifty students (chapter 3) has shown that flood risk salience among 15-year-old students is low and that their mental models with respect to flood risk are fragmentary. Students' mental models consist mainly of factual knowledge. Knowledge about connections between facts and about causes and effects largely fails. This also applies to knowledge about control strategies with respect prevention and flood preparedness.

Perception of flood risk

With respect to the cognitive aspects of flood risk perception, the perception of personal exposure, the perception of general exposure and the perception of the consequences are distinguished. In the flood-prone areas in the Netherlands, students' perception of personal flood exposure is significantly lower than students' perception of general flood exposure. This difference denotes that the optimistic bias is applicable to students' perception of flood risk. Although they have the notion that flooding in the Netherlands is possible, they do not apply this to their own situation. Students' low flood-risk perceptions are in accordance with the outcomes of studies among adults (Terpstra, 2009).

Perception of flood exposure and flood-risk salience

Although perception of personal flood exposure and flood-risk salience are not the same concepts, both are in line with each other. According to Tversky and Kahneman (1974) and Lindell and Perry (2004) salience influences risk perceptions. In this way the results of the survey have been elaborated by the interview outcomes: low flood-risk salience is in accordance with students' low perceptions of personal flood exposure. In addition, because the two results are measured in a different way, both results corroborate each other.

Trust in water safety

The survey showed that students' trust in water safety, just like in other studies (Terpstra, 2009), is high. Because it is important to determine what this trust was based on, questions about trust were incorporated in the interview protocol. The interviews showed that trust is not based on knowledge but on a general feeling

of trust in the Dutch authorities and their technical expertise. Therefore, high trust can be characterized as blind faith. This is in accordance with the results of Heems and Kothuis (2012).

Environmental cues

Flood-risk salience was measured by showing students, who were ignorant of the topic of the interview, pictures of situations in the surroundings. In fact, these pictures showed environmental cues concerning various kinds of potential threats, among which were pictures related to the threat of flooding. In the survey, the perception of environmental cues was measured by students' judgments of statements concerning environmental cues. In this way the low perception of environmental cues according to the survey has been elaborated by the outcomes of the measurement of salience at the start of the interviews. After all, the measurement of salience showed that although students were prompted by pictures with environmental cues, they didn't recognize the cues related to flood risk.

Knowledge about flood risk

Students' level of knowledge about water safety in general and with respect to their surroundings is low. The findings from the survey were corroborated and elaborated by students' mental models or knowledge structures that resulted from the analysis of the interviews.

How can students' flood-risk perceptions and preparedness intentions be explained? (Sub-question 2)

The survey analysis (chapter 2) made clear that while students' perception of flood exposure with respect to the surroundings is low, their perception of flood exposure with respect to the Netherlands in general is much higher. In addition, a regression analysis of the survey data showed that the variables fear, perception of environmental cues and local knowledge can be identified as predictors of flood-risk perception. Based on these results, it was decided to focus the interviews on the local situation in the surroundings of students' schools.

An important drawback of quantitative surveys is that questions tend to produce answers, especially when students do not have the possibility to choose the option 'don't know'. This implies that students' beliefs based on surveys are more or less prompted. It is not always clear whether these beliefs are existing beliefs or beliefs that are formed while answering the survey questions. By contrast,

students were prompted as little as possible by starting the interviews with open questions (chapter 3). In this way, it was possible to determine that part of the beliefs were not existing beliefs, but beliefs formed during the interview. The fragmentary mental models combined with the formation of beliefs while answering the questions, explains why students' reasoning was mainly based on the use of heuristics and analogies. The lack of local knowledge about flood risk is at the basis of low personal flood-risk perceptions. Both the survey and the interviews made this clear. This is also applicable to students' flood-preparedness intentions. Their ignorance with respect to this topic indicates the absence of preparedness intentions. During the interviews it became clear to many of the students that they were ignorant with respect to flood risk, preparedness and disaster response. At the end of the interview, more than 50% of the students had the opinion that they should know more about this topic.

***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?
(Sub-question 3)***

The design research approach applied, resulted in a flood-risk education program (chapter 4). The design was based on the understandings from learning theory, information processing and risk communication as well as the outcomes of the first phase of this thesis. The main starting point was that thinking of flood risk can be seen as a stepwise process starting with knowledge and understanding and taking account of various obstacles. Knowledge and understanding are related to the whole chain of events concerning flood risk in the surroundings (high water-dike breaches-flooding-consequences), as well as prevention measures and emergency preparedness. Based on analysis activities, consisting of a survey and interviews with students as well as a profound literature review, design principles were developed. In order to accomplish a program in which knowledge and understanding contribute to improved flood-risk perception and flood-preparedness intentions, the design was guided by the substantive design principles affect, availability and blended learning. Affect and availability are related to the way information is processed. If the information is intrusive and conceivable and if misconceptions might be overcome, this could lead to flood-risk awareness. Provided that flood-risk awareness is personalized and is not brushed aside by the idea "it won't happen to me", this awareness could result in flood preparedness. A requirement for influencing flood-risk preparedness intentions is that students' should be offered a balanced picture of both threat of flooding and potential coping measures.

In order to facilitate this stepwise process a variety of learning activities is necessary that enhances both experiential and analytical information processing. To establish these learning activities, the flood-risk education program, which was established together with geography teachers, is characterized by a combination of teacher- and student-oriented parts. The student-directed parts consist of a 3D-serious game, a 2D-flood simulation, fieldwork around a dike, societal discourse with relatives and friends, and a group-project about coping measures.

***To what extent does a flood-risk education program affect students' flood-risk perceptions and preparedness intentions?
(Sub-question 4)***

The intervention made clear that it is possible to raise the awareness that the surroundings can be flooded (chapter 5). Despite intrusive information, consisting of 2D-flood simulations in the surroundings and a 3D-game about dike breaches, perceived fear and perceived trust in water safety did not rise. These outcomes are in accordance with the aims of the flood-risk education program. By contrast, the perception of flood consequences as well as preparedness intentions and perceived knowledge about what to do during a flood, hardly changed. Apart from methodological reasons, this lack of change was possibly due to a shortage of intrusiveness of the information. But the use of more immersive simulation techniques within an educational setting could cause ethical complications.

The results of the intervention offered the opportunity to reflect on the design principles applied. The outcomes made clear that the three substantive design principles that guided the design of the intervention - *affect*, *availability* and *blended learning* - describe important functions and characteristics of the flood-risk education program. Nevertheless, we became convinced that an important principle should be added: *prolonged learning path*. There are two reasons for adding this design principle. Firstly, this has to do with the fact that attitudes change slowly. Secondly, attitudes towards flood risk are based on the awareness and understanding of natural and man-made influences on the scenery, fundamental ideas about the human-environment relation as well as the responsibility distribution within society. In order to achieve belief change concerning flood-risk preparedness, an education program of seven lessons is too short and more time is needed during a succession of classes in primary education and lower secondary education. Within this framework, it is important to mention that Hattie (2009) made clear that the number of exposures has a stronger effect on the learning outcomes than the length of exposure. The geography curriculum should consist

of a prolonged learning path in which these aspects are elaborated carefully with sufficient detail.

Main research question

In what way can geography education improve 15-year-old students' flood-risk perceptions and preparedness intentions?

The results of the studies conducted show that geography education can play an important role in raising flood-risk awareness and the acquisition of a realistic flood-risk perception, if the following design principles are taken into account:

1. The availability of flood risk in students' minds could be achieved by focusing on the surroundings of the school. Paying attention to the chain of events that are related to flood risk, including prevention and disaster response, improves the conceivability and understanding of flood risk.
2. To accomplish the appraisal of flood threat and preparedness in relation to students' personal well-being, evoking affective reactions by using immersive information is essential. In this way the obstacles of heuristics and biases can be overcome.
3. In order to accomplish both experiential and analytical information processing that underlie the formation of perceptions and intentions, the pedagogical approach should be blended. A combination of both teacher-directed parts as well as a student-directed parts should accomplish a variety of learning activities.
4. A prolonged learning path is needed in order to contribute to attitude change with respect to flood risk. Besides flood risk, underlying beliefs with respect to the human-environment relation should be taken into account.

6.3 Reflections

6.3.1 Reflection on research outcomes

The flood-risk education program aimed at deconstructing the "myth of dry feet". In order to change students' flood-risk perceptions and preparedness intentions,

the program should bring students in a position to redefine the environment, from primarily positive to an environment which can be threatening. The results of this thesis (chapters 4 and 5) showed that the program is useful and effective as regards the perception of flood-exposure in combination with the absence of adverse effects concerning fear and trust. It has become clear to the water boards that confronting people with potential effects of flooding is a useful method that can be used in risk communication, provided that is part of a balanced program that pays attention to both the threat and the coping measures.

The evaluation of the program only measured the overall effect of the program on perceptions. As a consequence, it is not clear which parts of the program, and to what extent, contributed to the formation of students' flood-risk perceptions. This is also applicable to the role of the individual design principles.

Because changes in preparedness intentions did not occur and the changes concerning the perception of flood consequences and self-efficacy were small, we propose some adaptations. With respect to the flood-risk education program, the effectiveness of 3D-serious game with respect to dike-failure mechanisms could be improved by using more immersive presentation techniques. Besides, it seems necessary to professionalize the teachers. After all, the role of the teacher is crucial in the learning process and "teachers make the difference" (Hattie, 2009, p.34). Furthermore, it has to be considered that attitudes in general change slowly and that perceptions with respect to flood risk are embedded in more fundamental beliefs about the human-environment relation, the manipulability of water safety and the responsibility distribution between citizens and the authorities. Therefore we propose that the flood-risk education program should be embedded in a geography curriculum for lower secondary education that takes into account these fundamental beliefs that form the basis for flood-risk perception.

6.3.2 Reflections on research design and approach

Research group

15-year-old students were the target group of this study. They represent the age group at the end of lower secondary education that has experienced three years of compulsory geography education. Their perceptions and knowledge with respect to flood risk are at the centre of this thesis. It is obvious that also geography teachers play an important role in raising flood-risk perceptions. On the one hand because their perceptions and knowledge of the topic are important but

especially because they play the leading role in modelling geography education in the classroom. Consequently, the perceptions of geography teachers are incorporated in chapter 2. Furthermore, teachers played an important role in the design, development and evaluation of the flood-risk education program (chapter 4 and 5). They participated in the formative evaluation of the flood-risk education program (chapter 4) and the intervention (chapter 5) that enabled the evaluation of the program. In hindsight, we may conclude that choosing students as the main target group was right because scrutinizing their perceptions and knowledge about flood risk yielded indispensable insights. However, this does not detract from the fact that education about flood risk could probably be improved by professionalizing the teachers on this subject.

Research design and approach

The phasing of the research design enabled us to start the research with an extensive analysis of the problem (phase 1). Besides an extensive literature review, the assumption that students' flood-risk perceptions were low, could be confirmed and deepened. The studies in chapter 2 and 3 gave us the opportunity to determine the explanations for students' flood-risk perceptions and preparedness intentions and to put students' perceptions, and the way they reason, in a theoretical framework. Preparedness intentions were studied only qualitatively. It would have been meaningful to study preparedness intentions also quantitatively.

Furthermore, the first phase was used to explore the way in which the regional water boards map out the potential threat of flooding technically. Besides the existence and usefulness of 2D-flood simulations, it became clear that water boards are reluctant with respect to making these simulations available for use in education. The experiment schools (phase 2, chapter 4 and 5) were located in an area that differed from the areas in which the schools that participated in the survey (chapter 2) and interviews (chapter 3) were located. Initially, it was supposed to locate the experiment schools in the same area. As a consequence, we could not make use of specific local information concerning students' perceptions. The limited co-operation of various water boards in making digital flood-simulations available, caused this inconsistency.

In the application of the principles of educational design research, drafts of the program and the final version were evaluated. The drafts were evaluated formatively during focus group discussions with teachers and the summative evaluation of the final version was based on the pre-test and post-test results of students. In this way, students did not play a role in the formative evaluation of the drafts.

Moreover, the summative evaluation was only based on the analysis of quantitative data. In hindsight, it can be concluded that the evaluation of the program as well as the systematic reflection-in-action on the design principles could have benefited from incorporating in-depth interviews with students.

In the course of this study a large part of the available time was used for phase 1 (chapter 2 and 3) as well as for the design of the flood-risk education program (phase 2; chapter 4). As a consequence, the time available for the intervention was limited. The time between the pre-test and post-test consisted of only seven weeks and the post-test was taken two weeks after the last lessons. Therefore, we only measured short term effects (Moody & Sindre, 2003). For longitudinal research that is focused on the long term effects, more time is needed.

This thesis focused on the role geographic education can play in raising flood-risk awareness and influencing flood-risk perception as well as preparedness intentions. In order to achieve this, not only learning theoretical and pedagogical understandings were incorporated. By making use of fundamental understandings from cognitive and social psychology as well as more applied understandings from risk communication research, the quality and the expressiveness of this thesis has improved. As a matter of fact, because risk perception is a multidimensional concept that is influenced by psychological, social and cultural factors, this multidimensional approach seems to be crucial.

6.4 Implications for the geography curriculum in lower secondary education

6.4.1 The geography curriculum in general

"Each mental space extracts and schematizes information useful for function in that space. So useful are these mental spaces that they subserve thinking in many other domains, those of emotion, interpersonal interaction, scientific understanding."

(Tversky, 2005, p.26)

The current set of attainment targets for geography in lower secondary education in the Netherlands has been formulated in a very general manner. They are only described on main features. Within this context it is obvious that the attainment targets do not contain any indication with respect to flood risk in the Netherlands.

As a consequence, the authors of geography textbooks in the Netherlands are free to deal with natural hazards in general and flood hazards in particular, in their own way. Often, natural hazards are used as a motivating vehicle to explain geophysical processes. Influencing risk perception or preparedness intentions is mostly not on the agenda. There are several reasons why geography education should contribute to flood-risk awareness and flood preparedness in the Netherlands:

1. Sea-level rise goes on and changes in water-safety policy result in communication efforts made by the Dutch authorities among which the Ministry of Infrastructure and Environment.
2. Students' personal flood-risk perceptions are low just like their levels of knowledge concerning flood risk and preparedness.
3. Knowledge and understanding that are necessary in attitude formation concerning flood risk are geographical in nature.
4. Dealing with hazards and information about potential hazards is becoming more important in an information rich society.
5. It makes the focus and contribution of geography education for society more explicit.

A curriculum is needed which is elaborated in such a way that it will be made clear to geography teachers, authors of textbooks, politicians and other non-geographers what geographical knowledge is most worth teaching and learning in lower secondary education, and how and with what goals natural hazards in general and flood risk in the Netherlands in particular, are part of the curriculum. We think that debate and research is needed to compile a more balanced geography curriculum that clarifies goals and contents. This is in accordance with an initiative of the Dutch State Secretary of Education, Culture and Science to start a nationwide discussion about what future students in primary and secondary education should learn (Ministry of Education, Culture and Science, 2014; www.onderwijs2032.nl). This should lead to a revision of the attainment targets that provides more support to teachers. The results of this thesis could be helpful in this process.

Needed to be elaborated is a geography curriculum in lower secondary education, in which the human-environment relation in general and natural hazards and flood risk in particular have a balanced position. In order to achieve this, debate among geography educators as well as research is needed. This is in accordance with the second recommendation made by Bednarz, Heffron, and Huynh (2013) in "A road map for 21st century geography education", concerning research that examines the components and characteristics of exemplary geography curricula. Fur-

thermore, it is in line with Lambert and Jones (2013, p.2) who stated that debate in geography education is constantly needed because of the importance to consider

"how to encourage appropriate pedagogy and content in an information rich society; how to organize education in the context of globalised neoliberal economy; how to decide what to teach children in a world which, we know for sure, is threatened in terms of its human occupation."

Besides, Rawding (2013, p.288) has claimed that geography has to change "in order to reflect and explain the changing nature of society and environment." Within this light, it is noteworthy that Lambert and Jones (2013, p.10) found it difficult to lend an ear to Michael Young's challenging phrase: "It is the importance of its concepts in the lives of young learners that gives geography its crucial role in the curriculum." If these concepts are organizational in nature, Lambert and Jones are right. After all, the (organizational) concepts as shown in Table 6.1 deal with the linking of ideas and experiences and are more pedagogical than geographical in nature (Brooks, 2013). On the other hand, when we understand concepts as substantive concepts, focusing on the contents, it seems less difficult to convince students and other non-geographers like politicians, what the relevance of these (substantive) concepts is. For example, the substantive concept of the human-environment relation which can be elaborated in the topic 'natural hazards' and which is described at the beginning of this thesis in the story of Tilly Smith, will probably easily convince students and other non-geographers of the relevance of geography. Showing this kind of convincing examples, is the only way to make the focus and contribution of geography education for society more explicit. According to van der Schee (2014) this is an important element in improving the position of geography education. The organizational concepts, concepts that should contribute to students' understanding, belong to the geography teachers'

Table 6.1 Examples of organizational concepts concerning geography education.

Big concepts according to Leat (1998)	Organizational concepts according to Taylor (2008)
<ul style="list-style-type: none"> - cause and effect - classification - decision - making - development - inequality - location - planning and systems 	<ul style="list-style-type: none"> - diversity - change - interaction - perception and representation

toolbox. The importance of these organizational concepts exists only in relation with the substantive concepts. Therefore, it is not surprising that history educators call these organizational concepts second-order concepts. It is recommended that newly formulated attainment targets with respect to geography education should primarily consist of substantive concepts, combined with organizational concepts.

In order to achieve a balanced geography curriculum, it seems obvious that developments in academic geography should be taken into account. Furthermore, other disciplines have embraced topics that are geographically relevant. Castree (2005) described the way topics concerning the human-environment relation were taken up by other disciplines. Illustrative of this evolvment is that various topics related to flood risk in the Netherlands are studied by non-geographers. Within this framework, it is not surprising that topics studied by other academic disciplines, but with a geographical relevance, could contribute to the aims of geography education (van der Vaart, 2001). With respect to natural hazards Lane and Coutts (2012) made clear how geographical knowledge of tropical cyclones relies on an understanding of underlying scientific processes and geographical concepts of scale, spatial distribution, interaction, and interdependence. In the light of the quotation of the psychologist Tversky at the beginning of this section, one could say that geography enables the formation of mental spaces or spatial representations that '*subserve other domains*'. Subserving other domains implies an integrative, spatial and place-oriented approach to these numerous domains. This approach makes these domains geographically relevant, not the domains in themselves.

6.4.2 Attainment targets with respect to flood hazards in the Netherlands

This thesis has shown that it is possible to strengthen students' flood-risk perception, but that influencing their preparedness intentions is difficult. Since the ultimate goal of flood-risk communication is related to changing attitudes with respect to flood risk and improving preparedness intentions as well as self-efficacy, this is a problem. This problem is topical since the Dutch Ministry of Infrastructure and Environment, which is responsible for water safety, has started a campaign in 2014 in order to persuade people that it is necessary to know what to do in case of a flood (www.overstroomik.nl). Dutch geography education could play an important role in influencing attitudes towards flood risk. This section therefore encloses a proposal for elaborated attainment targets concerning flood risk in the Netherlands as well as the foundations of these attainment targets. The proposal should act a substantive contribution to the current discussion about what future

students in primary and secondary education should learn (Ministry of Education, Culture and Science, 2014; www.onderwijs2032.nl).

A. The "myth of dry feet"

"Dutch citizens lack defensibility with respect to water safety because the notion of vulnerability is absent. This is caused by an idea of water safety which is a social construction that stems from 'the myth of dry feet'."
(Heems & Kothuis, 2012, p.393)

Heems and Kothuis (2012) concluded that "the myth of dry feet" is so deeply embedded in Dutch society that communication efforts about this topic arouse strong emotions and much incomprehension. The message that there will always remain a chance of flooding with enormous consequences, is understandable for citizens. But this message does not correspond to citizens' expectations with respect to water safety. The faith in the safety myth has instilled confidence into people that a 100% safety guarantee can be expected from the authorities.

According to Heems and Kothuis, "the myth of dry feet" is a social construction that stems from the way in which Dutch people think about three topics that play a fundamental role in societal discourse: the human-environment relation, the manageability of water safety, and responsibilities with respect to disaster management. With respect to the first two aspects, Heems and Kothuis described the way Dutch society perceived the role of water and the manageability of water safety since the 1953 flood disaster. While initially water was perceived as a part of hostile nature which should be overcome, this perception changed during the completion of the Delta Works. The idea arose that the water was defeated. Subsequently, nature and water got a 'friendly' status that even had to be protected. In this way, Heems and Kothuis claim that the idea of control over water has changed from a rational to a romantic idea of control. This movement is in accordance with Hinchliffe's (2007) description of how many people in western society think about nature. Nature is often experienced either as an 'independent state' or a 'dependent colony'. Nature as an independent state is related to the fact that nature is often experienced as distinct from the social world, as something which is 'out there' and not in our minds. Nature as a colony has to do with the way human imagination is able to perceive nature ideologically. In this line of thought, nature is incorporated in society.

In his fascinating reconstruction of the events and decision-making during the evacuation along the Rhine and Meuse in 1995, van Meurs (1996) claimed that people's reactions showed a loss of memory concerning periods of high water.

According to an expert in the field of dikes and water safety, quoted by him, many people had become alienated from the land they live in. This alienation shows resemblance with the way the human-environment relation has evolved according to Heems and Kothuis (2012).

The alienation from land and nature is influenced by technical modernization (Beck, 1992; Cohen, 1997). This modernization becomes apparent in the Dutch water works. And in line with Harvey (2005, p.248) who stated that "...in changing the world we change ourselves...", this modernization has also influenced the way people perceive the scenery. According to the philosopher Lemaire (1970) scenery is the projected relation between natural environment and human interference. The way in which people observe and discern the natural aspects of and the human impact on the scenery, has a strong influence on people's beliefs about the human-environment relation. With respect to flood risk, this means that the way people are aware of the effects of geophysical processes on the scenery as well as the technical interventions with which flooding is prevented, influence the beliefs about the manageability of water safety. Taking account of the studies in this thesis, we propose that risk communication targeting the deconstruction of "the myth of dry feet", should focus on the human-environment relation, while taking into account the foundations of these beliefs. These underlying aspects of "the myth of dry feet" are represented in Figure 6.1.

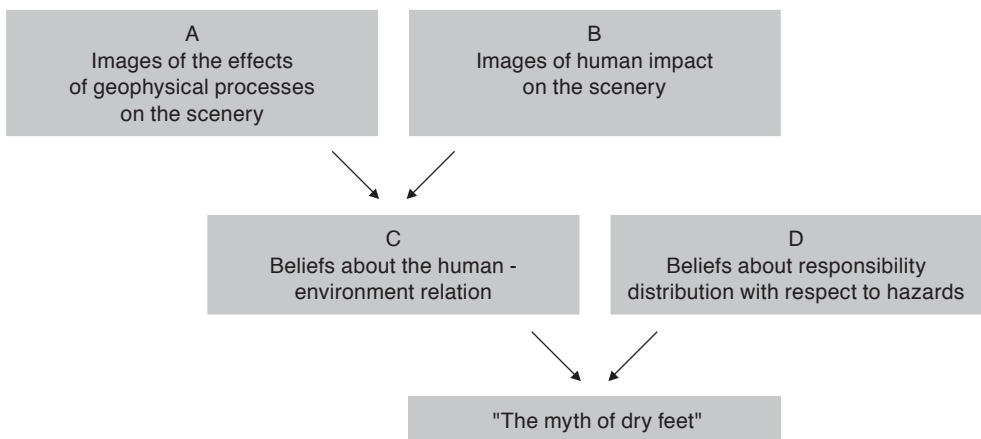


Figure 6.1 The underlying aspects of "the myth of dry feet".

B. Risk communication

"Effective risk communication requires sustained effort throughout the risk deliberation process, with learning along the way. This means that the resources that are needed are often far larger and the time required much longer than many risk managers anticipate. That lesson has not been learned and put into practice."
(Kasperson, 2014; p.3)

In this study, it is assumed that people's thoughts and judgments with respect to flood risk can be looked upon as a stepwise process (chapter 4). When risk communication underexposes or omits one of these steps, there will be a fair chance that people will not be fully alive to the message. Within the context of this thesis, this means that people are only inclined to think about flood risk and flood preparedness, if they are convinced of a potential threat of flooding that could hit them in their own surroundings.

When the authorities have the opinion that it is important to create a resilient society concerning flood risk in which citizens should be involved, it is important to realize that people's attitudes towards water safety are influenced by "the myth of dry feet". Furthermore, it is important to take in to account that attitudes change slowly and are influenced by complex structures of values and beliefs. Within this context, Heberlein (2012) made clear that attitudes are characterized by a vertical and horizontal structure. The vertical structure has to do with the fundamental values that underlie beliefs and with evaluative beliefs that influence an attitude. The horizontal structure implies that there are multiple vertical structures that underlie an attitude. Assuming that attitudes towards flood risk are formed by psychological, social and cultural factors, we suppose that the underlying aspects of "the myth of dry feet" play an important role.

C. Risk education

"The discipline of geography is at the core of vulnerability science, and we should not be bashful about this claim."
(Cutter, 2003, p.8)

Attitude change is a slow process in which emotions, value judgments and knowledge play an important role. Risk communication which is aiming at a resilient society with respect to flood risk, should take this into account. There are various reasons why education should be involved in this process. Firstly, because formal education can pay attention to a topic like flood risk more thoroughly. Renn (2008, p.258) states about this: "...being involved in educational programs has the

advantage that basic knowledge in applied sciences and basic understanding of probabilistic reasoning can be made the main target of the communication effort." In addition, Stoltman, Lidstone, and DeChano (2004, p.6) describe students as "one of the best diffusion agents for information about natural hazards, their occurrence, planned responses, and the means to mitigate effects."

Learning to deal with risks caused by natural hazards is a multidisciplinary topic par excellence. This topic is characterized by the interplay between geophysical processes and the way people at various places deal with it. As a consequence a wide variety of scientific disciplines are concerned with the topic. Earth science, hydraulic engineering, historical geography and planning are examples of relevant disciplines. In secondary education it seems obvious that geography as a subject pays attention to this. After all, geography is the only subject that deals with the interplay between physical and human systems in a spatial context while taking into account the characteristics of the location. If geography education has the intention to contribute to raising flood-risk awareness in the Netherlands this implies the following:

- I. The way geography education has contributed to the current beliefs and understandings concerning the underlying aspects of "the myth of dry feet", should be taken into account.
- II. Besides direct attention to flood risk like in the flood-risk education program (chapter 4 and 5), it is necessary to determine how geography education could contribute to more realistic understandings and beliefs concerning the underlying aspects of "the myth of dry feet". Only then, deconstructing "the myth of dry feet" is possible.

In the continuation of this section both aspects will be elaborated on.

D. Geography education and "the myth of dry feet"

In order to explain students' beliefs with respect to the underlying aspects of "the myth of dry feet", a set of possible causes was listed (Table 6.2). This was based on an interpretation of the interviews in chapter 3. The tentative conclusions that can be derived from these possible causes are that students in the Netherlands seem to live in a country with a footloose scenery. Furthermore, students' impressions of nature and technological interventions make them believe that the Netherlands is free from flooding. Research into the role geography education plays in

the formation of students' underlying beliefs is needed to corroborate the possible causes in Table 6.2.

Due to the fact that the attainment targets concerning geography in lower secondary education in the Netherlands have been formulated in a very general way, the contents of geography education are largely determined by the authors of textbooks. As it seems, this has also led to a somewhat kaleidoscopic character of the textbooks, which has contributed to the formation of a world view concerning both human geographical and physical geographical aspects. In this way, the aim of geography education as a subject of general education is dealt with. But this does not alter the fact that geography education should become aware of some more specific aims that are in line with societal needs. The attainment targets should therefore be reviewed and should be made more concrete. Within the community of geography educators, this should be discussed while answering the question what geographical knowledge is most worth teaching and learning. This is in line with the aforementioned initiative of the Dutch Ministry of Education, Culture and Science to discuss and review the attainment targets for primary and lower secondary education.

In this section we try to answer the question how the geography curriculum can be shaped in such a way that it contributes to a change of attitude regarding flood risk leading to positive intentions towards thinking about preparatory measures regarding flood hazards. With respect to flood risk, Heems and Kothuis (2012) emphasized the importance of focusing on the concept of vulnerability instead of the concept of risk. Both authors made clear that the concept of risk is usually connected with manageability. Acceptance of vulnerability is essential because geophysical processes like flooding remain unpredictable and capricious.

Table 6.3 shows a list of topics related to flood hazard education. By incorporating these topics, geography education could contribute to establishing a resilient society. The general conception of Heems and Kothuis (2012) with respect to the acceptance of vulnerability has been taken over as a guiding principle. This list serves as a foundation of the flood-risk education program and provides topics that should be incorporated in the attainment targets.

In order to give geography education the opportunity to contribute to raising flood-risk awareness and influencing flood-risk perception as well as attitudes towards flood-risk preparedness, it is necessary to include this subject in the legally prescribed attainment targets. Only then, flood risk will get a stable posi-

tion in the curriculum. Moreover, these attainment targets should make clear to teachers and textbook authors what aspects are needed. Taking Table 6.3 as a starting point, we would suggest that the attainment targets that are applicable to both primary education (age group 9 to 12) and lower secondary education (age group 12 to 15), should incorporate the topics A, B, C and D as mentioned in Table 6.4. Table 6.4 also shows the way these topics could be elaborated into learning goals. Furthermore, we suggest a fine-tuning between primary education and lower secondary education, which is based on the extent of the topics' complexity. During the successive classes, the attainment targets should not be focused on all at once. A differentiation based on Table 6.5 shows the way these learning goals could be phased over the classes. The proposed topics and learning goals should act as an input to the current discussion about what future students in primary and secondary education should learn (Ministry of Education, Culture and Science, 2014; www.onderwijs2032.nl).

6.5 Implications for further research into students' flood-risk perception

6.5.1 The formation of mental representations about flood risk

"At its most lofty, the mind rests on the concrete."
(Tversky, 2005, p.26)

The flood risk education program consists of teacher- and student-directed parts. As described in chapter 4, the mixture of parts should enable various types of learning activities. In the end, this mixture should prompt a stepwise process consisting of knowledge and understanding, flood-risk awareness and flood-risk perception, and flood-risk preparedness intentions. The first step is based on the assumption that the formation of mental representations of water levels and height differences along a dike as well as in geographical space, could be encouraged by a combination of virtual flood simulation and fieldwork. Furthermore, these mental representations on different scales should be tagged with information about historical events, dike-failure mechanisms and the process of flooding water. Since the evaluation of the program only measured the overall effect of the program on perceptions, it is not clear which parts of the program, and to what extent, contributed to the formation of students' mental representations.

Table 6.2 Quotations and possible reasons for students' beliefs about "the myth of dry feet".

	A Images of the effects of geophysical processes on the scenery	B Images of the human influence on the scenery	C Beliefs about the human-environment relation	D Beliefs about the division of responsibilities with respect to hazards
Quotations from students (from the interviews; chapter 3)	"I think just your feet will be wet, but not that extreme. In the end, it is just a river."	"I think that nowadays those dikes are so well constructed that they cannot breach"	"After all the dunes will be elevated every year. Maybe not every year, but they will be elevated when the sea water rises."	"I think that when such a thing will happen, there will be a weather alert so that you know in advance what will happen."
Possible reasons	- Of all the geophysical processes that students have in mind (flowing rivers, tides, storms), they can hardly imagine the dimensions and the variability.	- Students are not able to perceive whether objects in the scenery have a natural or man-made origin	- Students assume that insofar as geophysical processes in Netherlands play a role, these are fully controlled by human interventions. - Students suppose that the Netherlands can be fully protected against flooding with technical means.	- Students expect from the authorities that they guarantee water safety and that in case of an emergency the authorities will help and people will be any damage.

Table 6.3 The foundations of flood hazard education.

	A Images of the effects of geophysical processes on the scenery	B Images of the human influence on the scenery	C Beliefs about the human-environment relation	D Beliefs about the division of responsibilities with respect to hazards
	Focusing on vulnerability with respect to natural hazards in general and flood hazards in particular			
General direction	Changing the image of geophysical processes in the Netherlands and the students' surroundings from static or invisible to dynamic.	Changing the image of human interference in the Dutch scenery and in the scenery in the students' surroundings from invisible to dynamic and omnipresent.	Changing the idea of invulnerability into a notion that it is necessary to adapt continuously to altering conditions	Changing the image of the authorities' responsibilities with respect to prevention, warning and caring in case of a hazard or an emergency: from fully responsible caring to divided tasks and responsibilities between authorities and citizens.
Separate topics that enable geography education to contribute to realistic flood-risk education or the deconstruction of "the myth of dry feet"	<p>1 The current force of geophysical processes (rivers, sea, wind, tectonics) in the Netherlands and in the students' surroundings.</p> <p>2 The effects of geophysical processes in the Netherlands and in the students' surroundings in the near future.</p> <p>3 The geological structure of the substrate of the Netherlands and the students' surroundings, as result of geophysical processes in the geological past.</p>	<p>4 The historical geographical development of the scenery in the Netherlands and the students' surroundings, in particular with regard to water works. 5 The influence of economical, political and technical developments on the history and future of polders in the Netherlands.</p>	<p>6 The scenery of the Netherlands and the surroundings as the result of the interplay between geophysical processes and human interference in the past and at present.</p> <p>7 The way human interference influences geophysical processes as well as the unintentional side-effects.</p> <p>8 The way geophysical processes that are characterized by low frequency extremes are misinterpreted.</p> <p>9 The future of polders in the Netherlands</p>	<p>10 The complexity of modern society in densely populated areas with respect to transport of freight traffic, food supply, passenger transport and public functions with respect to energy and water.</p> <p>11 The limited possibilities authorities have in case of a hazardous calamity.</p> <p>12 Self efficacy for coping with hazardous situations.</p>

Table 6.4 Topics and learning goals related to flood risk in the Netherlands.

Topics	Learning goals
A Geophysical processes in the Netherlands	A1 - Students are able to describe and explain the formation of the Dutch scenery and the scenery in their surroundings caused by geophysical processes. A2 - Students are aware that geophysical processes play a role in the scenery in their surroundings at this time.
B Human influence on the Dutch scenery	B1 - Students are able to describe and explain the formation of the Dutch scenery and the scenery in their surroundings caused by human interferences. B2 - Students are aware that human interferences play a role in the scenery in their surroundings at this moment.
C Relation human-environment in the Netherlands	C1 - Students are able to describe and explain how geophysical processes and human interference are related in the Netherlands and in their own surroundings. C2 - Students in flood-prone areas realize that their own surroundings and they themselves are vulnerable to flood hazards caused by the sea or the main rivers. C3 - Students realize that the vulnerability with respect to flood hazards differs within the Netherlands.
D Responsibilities with respect to flood risk	D1 - Students are able to describe and explain how responsibilities are divided among the authorities and citizens. D2 - Students have the intention to think about preparedness in case of a flood hazard.

Table 6.5 The phasing of the learning goals (In order to compare, the British key stages are included).

Age group	Dutch education	Stages in British education	A1	A2	B1	B2	C1	C2	C3	D1	D2
9-10	Primary education	Group 6		X							
10-11		Group 7		X		X					
11-12		Group 8	Key stage 3	X	X	X	X		X	X	
12-13	Lower secondary education	Secondary 1	X	X	X	X	X	X	X		
13-14		Secondary 2	X	X	X	X	X	X	X	X	X
14-15		Secondary 3	Key stage 4	X	X	X	X	X	X	X	X

Tversky (2003) made clear that describing mental representations of familiar environments as 'cognitive maps' could lead to misunderstandings. This is caused by the fact that environmental knowledge often consists of information which is not maplike at all. Therefore, the term 'cognitive collage' should be preferred because the environmental knowledge making part of these mental representations has a variety of forms and is the result of imagining the environment either from a route perspective or a survey perspective or both. In this way memory and judgments about the environment can be easily end up with distortions of the facts.

The mental representation the flood-risk education program is aiming at, is based on existing cognitive collages students already have. Furthermore, the flood risk education program tries to improve these cognitive collages by combining various types of information on different scales. Although we, as well as the consulted educational experts on teaching, have the impression that this method might be successful, we have not determined specifically what influence it has on the formation of students' cognitive collages concerning their surroundings. Further research is needed to determine how cognitive collages are formed, how information is tagged to places, what geographical information systems can best be used and in what succession the various aspects should be introduced. To establish this research, combining both geographical and psychological understandings, seems crucial.

6.5.2 The flood-risk education program and other regions in the Netherlands

In the course of 2015 the flood-risk education program as described in chapter 4, will be adapted to other flood prone areas in the Netherlands. This is due to an initiative of the Royal Dutch Geographical Society (Dutch: KNAG) and the financial support of the Ministry of Infrastructure and Environment, Rijkswaterstaat (the Department of Waterways and Public Works) and two water boards (Hoogheemraadschap Hollands Noorder Kwartier and Waterschap Rivierenland). Besides the regional context, the adaptations also deal with incorporating newly developed online material from Rijkswaterstaat concerning evacuation strategies and self-efficacy (www.overstroomik.nl). This new project that will start in 2015, provides the opportunity to evaluate the adapted flood-risk education program (chapter 5) in other areas in the Netherlands. Furthermore, the reported limitations (chapter 5) concerning the measurement of preparedness intentions and the presentation mode could be overcome.

6.6 Implications concerning some aspects of pedagogical content knowledge

6.6.1 Pre-existing knowledge and misconceptions as the basis for conceptual change

"The process of learning is a journey from ideas to understanding to constructing and onwards. It is a journey of learning, unlearning, and overlearning."
(Hattie, 2009, p.29)

In this thesis, identifying students' existing mental models with respect to flood risk played a vital role in the research design. The outcomes showed fundamental misconceptions and gaps in these mental models. These results played an important role in the design of the flood-risk education program. This was based on viewpoints originating from science education research. In line with Lane and Coutts (2012), it is necessary to emphasize the importance of understanding students' existing conceptions by quoting Shulman (1986, p.10) who stated that this understanding should be "at the heart of our definition of needed pedagogical content knowledge". This is in accordance with Reinfried's claim (2006, p.58) that "as long as instructors are not aware of the existence of preconceptions and of the necessity to clarify them, they cannot help their students to change their misconceptions". Although some authors have downplayed the importance of misconceptions in conceptual change (Smith, diSessa, & DeCoster, 1993; Taylor, 2013), we agree with Vosniadou (2003) who made clear that restructuring intuitive beliefs is complicated because many concepts are counter-intuitive. It seems obvious, that under these circumstances conceptual change cannot take place by "assimilating new information into existing knowledge structures" (Vosniadou, 2003, p.379). With respect to conceptual change in relation to groundwater, this is acknowledged by Reinfried (2006).

In the light of the aforementioned, it is important that more pedagogical research is done concerning preconceptions, misconceptions and reasoning among students with respect to various geographical topics. This type of research should not be limited to physical geographical topics. Geography teachers should be provided with the outcomes of these studies. Furthermore, this type of research should play an important role in teacher education. We support Reinfried's argument (Reinfried, 2006) to facilitate students in teacher education with the skills and strategies to diagnose students' preconceptions.

6.6.2 Intuitive thought and misconceptions

A. Introduction

"For although we are accustomed to separate nature and human perception into two realms, they are, in fact, indivisible. Before it can ever be a repose for the senses, landscape is the work of the mind. Its scenery is built up as much from strata of memory as from layers of rock."
(Schama, 1995)

The quotation from Schama's book 'Landscape and memory' is in accordance with the constructivist approach. The way people perceive a landscape in general or a dike in particular 'is the work of the mind'. One of the main questions of this thesis has to do with the mental processes underlying flood-risk perception.



Figure 6.2 Students' intuitive and analytical thoughts when observing a dike (fictional).

Chapters 2 and 3 made clear that the way students think about dikes plays a role in the way they judge flood risk and flood consequences. Their judgment is strongly influenced by heuristics, common sense reasoning and biases. That students who are living in flood-prone areas in the Netherlands appear to be "prisoners of their experience" (Kates, 1976; p.151), is reflected in the way they reason about flood risk. Therefore it is obvious that students' thoughts agree more often with the thoughts of student 1 in Figure 6.2 than with those of student 2.

Mental processes that are widely accepted in cognitive psychology are applicable to the way students in secondary education think and reason about flood risk. It seems plausible to assume that the awareness of these mental processes is essential for understanding the way students think, reason and judge about various topics that belong to a variety of school subjects. In this section we will successively describe the dual process modes of thinking and the way these modes are reflected in thinking about flood risk. Finally, we try to find out whether and how dual process modes of thinking are incorporated in the way educational psychology pays attention to thinking processes.

B. Dual process modes of thinking

"When you are asked what you are thinking about, you can normally answer. You believe you know what goes on in your mind, which often consists of one conscious thought leading in an orderly way to another. But that is not the only way the mind works, nor indeed is that the typical way. Most impressions and thoughts arise in your conscious experience without your knowing how they got there."
(Kahneman, 2011; p.4)

As described in chapter 4, dual-process models of information processing are widely accepted and discussed in social and cognitive psychology (Evans, 2008; Smith & DeCoster, 2000). On the one hand, there is the experiential mode of thinking, which is intuitive, affective, associationistic, rapid, automatic and effortless. On the other hand, there is the analytical mode which can be characterized as logical, conscious, slow and effortful. In his popular book "Thinking, fast and slow", Kahneman describes in an accessible way the characteristics of both modes of thinking. He describes the two modes of thinking as system 1 and system 2. He suggests that the brain/mind can be described as an associative machine (system 1) that continuously processes stimuli from the outside world while monitoring automatically whether these stimuli could be threatening. As long as the stimuli are classified as not threatening a situation of cognitive ease

will persist and conscious analytical processing of information (system 2) will stay away. In this situation the mind is prone to the use of judgmental heuristics that lead to biases. Keren and Schul (2009) made clear that there is no empirical evidence for the existence of two separate systems. By distinguishing two systems, it would be wrongly assumed that both systems can be characterized by 'binary characteristics or dichotomies'. According to Keren and Schul the characteristics are 'inherently continuous'. In accordance with both authors, Kahneman (2011) made clear that the two systems are fictions which are used as metaphors of agency in order to make it more accessible for lay people.

The concept of 'bounded rationality' was introduced by Simon (1955) and further elaborated by Tversky and Kahneman (1974). This concept implies that people's thinking and decision making can be looked upon as boundedly rational. Besides deliberate thought, intuitive beliefs play an important role. The mind has its restrictions because of its limited capacity, the limited time available in making decisions as well as the unreliable information which is available. As we have seen in this study, intuitive thought plays an important role in risk assessment. Nevertheless, intuition or the experiential system has its limitations and can misguide people (Slovic et al., 2004).

The two modes of information processing play an important role in two well-known models concerning persuasive communication, the Elaboration Likelihood Model (Petty & Cacioppo, 1986) and the Heuristic model of persuasion (Chaiken, 1987). With respect to learning processes, it is obvious thinking plays an important role. Therefore the question seems justified in what way dual process modes of thinking play a role in educational psychology?

C. Thinking fast about flood risk

"A goal is to introduce a language for thinking and talking about the mind."

(Kahneman, 2011; p.13)

This section shows how heuristics and biases play a role in the way students reason about and judge flood risk. Therefore some of the striking examples of Kahneman (2011) are applied to cases that are related to flood risk. The examples are derived from chapter 2 and 3 and make concrete how students' thinking can be interpreted.

Table 6.6 shows several examples of argumentations each consisting of two statements and a conclusion. The composition of the argumentations was inspired by outcomes of the interviews with students (chapter 3). Lay people, like students, will judge the first three argumentations (1,2, and 3) intuitively as plausible and logically valid. But although the first two statements in the three examples are correct, the conclusions are not. According to Kahneman (2011), peoples' associative brain is inclined to invent plausible stories based on the available ideas which gives them a feeling of cognitive ease, especially when the conclusion is in accordance with the prevailing views. The cognitive ease withholds people from analyzing the statements and conclusions thoroughly. This is an illustration of the confirmation bias. The fourth argumentation (4) is logically valid. But the chance that lay people judge this argumentation as right and that they are aware of the consequences, is not very high. The message will be received with disbelief because it is not in accordance with the prevailing views. Thus, this is an illustration of the belief bias (Evans, Barston, & Pollard, 1983).

Table 6.6 Argumentations about flood risk.

Argumentations	
1	<ul style="list-style-type: none"> - The chance that the Netherlands will be hit by flood is small. - The Dutch authorities do everything to prevent the Netherlands from flooding. ▶The Netherlands is invulnerable for floods.
2	<ul style="list-style-type: none"> - The media and geography textbooks are full of news items concerning dike improvement. - Warnings for flooding do not occur. ▶I will not be threatened by floods.
3	<ul style="list-style-type: none"> - Dikes in Netherlands are stronger than anywhere else in the world. - Reports of flooding are only found abroad. ▶Floods do not occur in the Netherlands.
4	<ul style="list-style-type: none"> - All dikes and dunes in the Netherlands are checked on firmness, every five years. - Due to these inspections, a part of the dunes and dikes is disqualified. ▶There will always be a chance of flooding.

Chapter 2 consists of a quantitative study in which students were asked to judge statements about flood risk. Table 6.7 shows two of those statements. Kahneman (2011) made clear that in case someone is confronted with a difficult question, the possibility exists that people unnoticed replace that 'target question' with a 'heuristic question'. With respect to the first statement, the substituted statement could have been: 'Thinking about flooding in the surroundings of my school makes me anxious'. The judgment of this statement is much easier and comes automatically and the answer will be adapted to the judgment of the 'target statement'. In this

example the nature of the heuristic statement has to do with emotion. Thus, the affect heuristic seems to be applicable to this example (chapter 2).

Table 6.7 Examples of statements.

Do you agree with the following statements:	
1	'I think the surroundings of my school could be hit by flooding'
2	'I think the surroundings of the school are protected well against flooding'

As far as the second statement is concerned, the substituted statement could have been: 'As far as I know, there has never been a dangerous situation or dike breach'. In this example the nature of the heuristic statement has to do with the lack of experience with threatening situations. In this way, the availability heuristic seems to be applicable to this situation (chapter 2).

Table 6.8 Students' reasoning about flood safety.

<p>"My parents once told me about the evacuations in 1995. For days the water had been high against the dike. After five days, they were allowed to return and nothing had happened. According to my father it had not been at all necessary, after all, the dikes had held it anyway. And he's right. Last winter, once again the water was against the dike, and nothing happened. These dikes are just strong enough."</p>

One of the students who participated in the interviews (chapter 3) explained why his trust in flood safety was so high (Table 6.8). This student's explanation seems to be a coherent story. It shows the ease and certainty with which, in hindsight, the conclusion was drawn that the dikes are safe and the evacuation was needless. Furthermore, this explanation shows the ease with which 'associative coherence' between repeated moments of high water and the absence of flooding is used to draw the conclusion. People reason that the absence away of flooding was caused by the quality of the dikes. Their reasoning is intuitively initiated by the associative mind that invents a coherent story by using activated ideas. In fact the quality of the dikes was very problematic and it was by chance the dikes did not fail. Hence, this is an illustration of the hindsight bias as described by Kahneman (2011). The search for causality, often based on just a few facts that are easily associated, is innate. It is an automatic operation which is characteristic of intuitive thinking which is called causal intuition.

D. Thinking in education

"Teachers need to provide students with multiple opportunities...leading to students building constructions of this learning. What is required are teachers who are aware of what individual students are thinking and knowing ...to provide meaningful and appropriate feedback."
(Hattie, 2009, p.36)

During the last decades there has been a tendency to emphasize the importance of thinking skills in education (Caine, Caine, McClintic, & Klimek, 2009; Lipman, 2003; Marzano & Miedema, 2007). This was partly influenced by the appearance of social constructivism. Various types of thinking have been distinguished like problem-solving thinking, reflective thinking and critical thinking. In his comprehensive book 'Thinking in education', Lipman (2003) states that "I think we are much better off construing critical thinking as nurturing in students a tentative skepticism than as nurturing in them a set of beliefs of dubious long-term reliability." According to Bereiter (2002, p.30), this tendency could lead to the replacement of 'product' (subject-matter) by 'process' (thinking skills): "...to espouse 'constructivism,' 'social construction of knowledge,' 'inquiry,' 'critical thinking,' and other noble processes. That is but another road to reductionism, however, to activities that have lost contact with their goals." Moreover, Hattie (2009) and Bereiter (2002) have put social constructivism in perspective by stating that "...constructivism is not a theory of teaching, but a theory of knowing and knowledge, and it is important to understand the role of building constructions of understanding" (Hattie, 2009, p.26). Although there is a focus on thinking and thinking skills, there is discussion whether thinking processes are an explicit aim in themselves or an implicit means in order to enhance constructing and understanding the subject matter.

Within this framework it is remarkable that with all the attention to thinking skills and students' constructions of understanding in education and educational psychology, hardly any attention seems to be paid to dual process modes of thinking as studied in social and cognitive psychology. When higher order cognitive functioning, implicitly or explicitly, is at least an important means that should lead to better understanding among students, it is important for teachers to be aware of other, even more dominant, types of cognitive functioning that may be the cause of misunderstandings. Indeed, the neuroscientist Bar (2007, p.281) made clear that "...associative activation is an integral process of the brain's mental 'default' mode." And Carbonell and Minton (1983) stated "...we claim that formal deductive inference (=logical reasoning) is definitely not the dominant process in mundane

reasoning. In essence, the experiential reasoning hypothesis states that structuring new information according to relevant past experience is an important aspect of human comprehension....". This is in accordance with Kahneman's metaphor of the mind as an associative machine.

It seems as if within education and educational psychology everyone assumes that serious students' reasoning is logical and based on analytical information processing, without realizing that the 'mental default mode' is intuition. But students in classrooms are the same human beings that are prone to the use of judgmental heuristics that lead to biases as targeted by Kahneman. Although most teachers will intuitively know that students' intuitions play a role, it is necessary for them to master a language with which they are able to understand and explain how misunderstandings arise. And these misunderstandings could just as well be the result of complicated subject matter as of misleading analogies, heuristics, biases and common sense reasoning. Being able to indicate the causes of misunderstanding will enable teachers to give students the vital feedback. The importance of pre-existing knowledge in the learning process as well as in misunderstandings has already been acknowledged within education. But the mental processes that could cause these misunderstandings are hardly mentioned.

It is remarkable that the role of intuitive beliefs as part of the concept of 'bounded rationality' has penetrated into many disciplines (Kahneman, 2011), but hardly reached education. Within the literature on educational psychology or the pedagogical/didactical literature used in teacher training, almost no attention is paid to the essence of the dual process modes of thinking.

This section has shown just a few examples of the way intuitive thought plays a role in thinking and reasoning, but there are many more relevant aspects. In order to enhance learning processes and the way teachers are able to fathom students' thinking, it is necessary to provide them with insight in this part of cognitive psychology. It is therefore strongly recommended to incorporate this topic, which can be considered as pedagogical content knowledge, in teacher training and refresher courses for teachers.

6.6.3 Epilogue

Finally, we will put the extraordinary story of Tilly Smith, which is described in the preface of this thesis, into the perspective of the aforementioned. On the 26th of December 2004, Tilly Smith was in Thailand, when this part of the world was hit by a tsunami.

"I remembered because I'd been taught it in the geography lesson. It was the exact same froth, like you get on a beer. It was sort of sizzling. I said, "There's definitely going to be a tsunami." My mum didn't believe me. She didn't react, she just kept on walking."

The reaction of Tilly's mother was an intuitive reaction based on common sense. Actually, she was 'prisoner of her own experience' and she couldn't think the unthinkable. The necessary knowledge was not available in her mind and this influenced the judgment of her daughter's warning. Tilly herself was able to make a connection between the cues she saw and heard on the beach in Thailand and the general concepts concerning tsunamis she had learned during her geography lessons. This type of application of theoretical concepts in a new context (Thailand) is a good example of transfer. Achieving this type transfer, is in general one of the big challenges in education. It would not have been strange if Tilly, on holiday at the other side of the world, would have reacted intuitively while relying on her lack of experience with tsunamis. However, by recognizing, interpreting and making inferences the way she did, indicates analytic thinking. By the associations and mental simulations she made, she was not inclined to neglect the cues that preceded the unimaginable. Nor did her analysis lead to panic. Indeed, she had never experienced a tsunami, but she had only had geography lessons that obviously enabled her to construct the correct images and predictions. Apparently, Tilly's geography teacher had accomplished the ideal transfer and had taught her to understand the true nature of the tsunami and to recognize the cues in such a way that she perceived a tsunami as something very serious and consequently had the appropriate intentions to act.

Do you know what's the best thing you can do during a flood?

"No, not really. But your instinct tells you to go to the highest point. Dutch people are good swimmers too. But you can't carry on swimming for hours. I think that in our country the emergency services will be quickly on the spot, the fire brigade for instance."

