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The role of knowledge in students' flood-risk perception

Abstract

Until now flood risk perception in the Netherlands has been solely studied as it relates to adults. This exploratory study focused on 15-year-old students who have taken geography courses for 3 years. Since geography education focuses on the formation of knowledge and understanding with respect to flooding in the Netherlands, we were interested in finding out to what extent knowledge and understanding of flooding leads to a rational judgment of flood risk that influences flood-risk perception among 15-year-old students. A cross-sectional survey was conducted among 483 15-year-old students from different flood-prone areas in the Netherlands. A reference group of 134 students from higher-elevation areas also participated. In addition to risk perception and risk-related factors, the survey also consisted of a knowledge test about flood hazards and water management with respect to the Netherlands in general and with regard to the surroundings of the students' schools. In general, students showed low personal flood-risk perceptions and much stronger general flood-risk perceptions. Students' level of knowledge of floods and flood-related aspects was low. Predictors of personal risk perception included fear, knowledge of flooding in the surroundings of the school and the awareness of environmental cues. Further study is needed of the formation of knowledge in relation to engendering flood-risk awareness among students.

Key words:
- knowledge of floods
- flood-risk perception
- 15-year-old students
- geography education

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2.1 Introduction

For centuries, the Netherlands has faced the threats of the sea and rivers. About 25% of the country lies below sea level and about two-thirds would be flooded frequently without flood defences. Besides, part of the Netherlands belongs to the floodplains of the Rhine and Maas rivers. Both the coastal plain and the floodplain are protected by dunes, dikes and dams. Over the last 1000 years catastrophic floods have taken place regularly. Two major floods during the 20th century were followed by huge projects to prevent the country from any further flooding.

Various studies (Intomart GfK, 2010; Terpstra, 2011) have shown that people in the Netherlands are hardly worried about flood-hazards. Threat awareness of flooding is low, trust in flood-risk management is high, the likelihood of flooding is assessed as low, and few people tend to be prepared for possible flooding. It seems plausible that these beliefs derive from the huge attention to the water projects that have been accomplished during the 20th century and from the idea that the national water authority in the Netherlands has taken care of all the safety measures in an excellent way. The geography curriculum in primary and secondary education has also contributed to these beliefs. All students have been taught about the Delta Project in the south-western part of the Netherlands as well as the project around the Lake IJssel. In this way the geography curriculum has always focused on safety measures without mentioning the consequences of a disastrous flood.

Because of the impact of climate change and the related possible sea-level rise and the attention to the devastations of Hurricane Katrina in 2005, the Dutch government has focused again on flood safety. Despite the high safety levels and the big efforts to prevent the country from flooding, it is clear that there remains a flood risk. Therefore, the government has taken the initiative to prepare the inhabitants for possible flooding (Ministry of Transport, Public Works and Water Management 2006). Among other things, this will involve raising peoples' awareness of the possible threat of flooding (Deltacommittee, 2008) in order to convince them of the usefulness of preparedness.

Until now, risk perception research with respect to natural hazards has focused to a large extent on adults. Few risk perception studies have been undertaken among children and students (Ronan, Crellin, & Johnston, 2010). Several authors have emphasized the importance of the role that school education can play in raising students' awareness of hazard-related risks and in indirectly increasing the awareness of students' families (Ronan & Johnston, 2001; Shaw & Kobayashi, 2001). This present study aims at exploring flood-risk perception and hazard knowledge among 15-year-old students in the Netherlands. Moreover, this study investigates the role of knowledge, fear, trust and environmental cues in the shaping of students' flood-risk perception.

2.2 Theory and expectations

2.2.1 Risk perception

"Risk perception is the subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences" (Sjöberg, Moen, & Rundmo, 2004, p.8). In the shaping of risk perception, the awareness of the possibility to get exposed to a threat plays an important role. Lindell and Perry (2004) call this 'threat belief'. According to Mileti and Peek (2000) the extent to which threat belief is personalized, influences risk perception. In our study the perception of personal flood exposure plays an important role in determining risk perception.

When lay people are asked to judge risks, they make use of experienced events and information they can easily remember. This is called the 'availability heuristic' (Slovic, Fischhoff, & Lichtenstein, 1981). According to Slovic, Finucane, Peters, and McGregor (2004) dual-process theories of thinking, knowing and information processing are applicable to lay people's risk perception. It is the experiential mode of thinking in which risk perception is based on intuitive feelings, according to Slovic et al. (2004). This reliance on feelings is called the 'affect heuristic'. According to Finucane, Peters, and Slovic (2003), the experiential mode of thinking and the analytic mode of thinking are inseparable ("the dance of affect and reason"). Slovic et al. (2004, p.314) made clear that "…it is unlikely that we can employ analytic thinking rationally without guidance from affect somewhere along the line." Lay people's risk perception is influenced by affective and cognitive processes. In this study, we expect that this is also applicable to students' flood-risk perception.

It is generally expected that adolescents judge risks differently from adults (Cohn, Macfarlane, Yanez, & Imai, 1995). Elkind's (1967) concept of adolescent egocentrism forms the theoretical basis for this assumption. Adolescents are said to believe in a "personal fable" of uniqueness that makes them feel invulnerable to harm. Hence, this feeling is thought to increase their unrealistic optimism with respect to risks. According to Millstein and Halpern-Felsher (2002), a few studies have tested this hypothesis by comparing adolescent and adult risk judgments. These studies, with respect to health behaviour, showed opposite results. Cohn et al. (1995) found lower risk perceptions among adolescents than in adults, while Quadrel, Fischhoff, and Davis (1993) found stronger feelings of invulnerability among adults compared to adolescents. Hermand, Mullet, and Rompteaux (1999) reported with respect to hazardous activities and technologies, higher risk ratings for adolescents compared to adults. Millstein and Halpern-Felsher (2002) studied risk perceptions with respect to natural hazards and behaviour-linked risks and found higher risk perceptions and weaker feelings of invulnerability among adolescents compared to adults. Millstein and Halpern-Felsher (2002) concluded that research up to that time had not supported the idea of adolescent invulnerability. But this conclusion should be treated with caution because the results of these studies are hardly comparable due to methodological differences. Millstein and Halpern-Felsher stated that future studies are needed to judge whether adolescents and adults judge risks to the same degree.

2.2.2 Hazard knowledge

According to Kellens et al. (2012), the variable knowledge has hardly been tested in relation to flood-risk perception. In most studies concerning knowledge and flood-risk perception, the variable knowledge has been operationalized as perceived knowledge or self-reported knowledge. In different theoretical models concerning risk perception and risk behavior, knowledge forms part of the model. The Protective Action Decision Model (PADM) (Lindell & Perry, 2004) tries to explain people's protective-action decision making. In this model the decision-making process is described in successive steps with respect to threat appraisal and the assessment of potential coping behaviour. According to the PADM, together with other factors, hazard knowledge plays a role in this process because it influences the way people pay attention to and comprehend risk information prior to the decision-making process. Lindell and Perry discerned three types of hazard knowledge: knowledge of hazard genesis, knowledge of the mechanisms of exposure and knowledge of types of hazard adjustments. Renn and Rohrmann (2000) developed a model of risk perception in which they integrate psychological, social and cultural factors. In this model knowledge, which is influenced by cultural and social factors, affects heuristic information processing that underlies risk judgments.

According to Lindell and Perry (2004) hazard knowledge differs from hazard awareness. Hazard knowledge is characterized by “the depth of an individual’s understanding of the hazard”. But the effect of hazard knowledge on risk perception can be the opposite (Lijklema, 2001). Knowledge may cause a reduction of fear because people get more acquainted with the risk. On the other hand, the availability of the hazard and its consequences may intensify risk perception. Bostrom, Fischhoff, and Morgan (1992) emphasize the idea that lay people’s substantive knowledge of “what a hazard is and how it works” is essential. Shaw, Shiwaku, Kobayashi, and Kobayashi (2004) made use of a model in which knowledge is at the beginning of a sequence: knowing, realizing, deepening, decision and action. They stressed that knowledge is coming from different sources: experience and education. Moreover, they made clear that school education has its limitations, family and community also play an important role. But school education is useful for “the very first step, which is providing knowledge and activating students’ interest” (Shaw et al., 2004).

Various studies have shown that people with higher levels of hazard knowledge are more likely to adopt hazard adjustments (Lindell & Perry, 2004). On the other hand, Lindell and Perry (1993, p.164) stated that “…detailed hazard knowledge is not a necessary condition for initiating hazard adjustments”. They continued by stating that residents only need to believe that the threat really exists and protection is needed. The question is what makes people believe or think that a threat really exists. What kinds of knowledge affect and reinforce risk perception? Botzen, Aerts and van den Bergh (2009) studied the influence of knowledge about the causes of floods on risk perception in the Netherlands. They found that people with little knowledge about the causes of floods have lower risk perceptions.

Johnson (1993) has made some critical remarks about the research on the role of knowledge in lay risk perception. He emphasized that, in general, poor definitions of knowledge have been used. Knowledge is too often measured as a set of isolated facts instead of knowledge as a set of conceptual structures. Furthermore, he emphasized the importance of combining both indirect knowledge and knowledge based on personal experience. It is important to emphasize that the role of knowledge may differ between hazards in general and also between natural hazards in particular. According to Terpstra (2011), the visibility of flood defences in the Netherlands may have an effect on people’s flood-risk perception. The question is whether people, while looking at dikes, are aware of the function of dikes and dams as flood-defence mechanisms. It seems plausible to assume that people’s background knowledge together with their imagination and interpretation of the topographical situation with which they observe the flood defences could play a role in the awareness of dikes and dams. A dike could be seen as a part of a flood-defence system but it could also be perceived as slightly elevated land.

2.2.3 Environmental cues

According to the PADM (Lindell & Perry, 2004) environmental cues are one of the two sources of information that precede the decision-making process. The influence depends on three pre-decisional processes: exposure to, attention to and interpretation of environmental cues. It is said that environmental cues under normal conditions suggest safety rather than danger (Lindell & Perry, 2004). With regard to flood hazards, stormy weather and high water levels are environmental cues that could precede a potential dangerous situation. Even though young students in the flood-prone areas in the Netherlands have never experienced flood hazards in their surroundings, they have all gone through situations with stormy weather and higher water levels than usual. The question is whether students are aware of and remember such situations and to what extent they perceive such stormy weather and high water levels as dangerous. Hazard knowledge seems to be a prerequisite for the right interpretation of environmental cues. In this study, we intend to explore whether flood-risk perception is influenced by these types of environmental cues.

2.2.4 Fear and Trust

Loewenstein, Weber, Hsee, and Welch (2001) made clear that cognitive evaluations of risk probability and risk consequences give rise to emotional reactions. On the other hand, they state that influence operates in the reverse direction, from emotion to cognition. In line with the 'affect heuristic' (Slovic et al., 2004) the images in people's minds are marked with affect. These affect-laden images influence judgments. In this study, we explore to what extent perceived fear with regard to flooding influences students' flood-risk perception.

Many people in the Netherlands are still aware of the last catastrophic flood event that hit the south-western part of the country in 1953. Most of them know of the huge flood defence projects that followed. In the geography course books that are used in secondary education, this is and has always been a major topic, and the safety of the flood defences has always been emphasized. Therefore it seems plausible to assume that students' trust in the quality of the flood defences and the water boards is high, on both a regional and national level. Trust plays an important role in risk perception, especially when people are lacking knowledge. The complexity of hazardous situations can be reduced by trust (Siegrist & Cvetkovich, 2000). According to Poortinga and Pidgeon (2003), trust is a "complex and multidimensional" concept in which perceived competence, objectivity and fairness play an important role. Although trust shows similarity with affect, Terpstra (2009) made clear that cognitive evaluation of (flooding) risk is also related to trust. He has studied the role of trust in risk perception in three different flood-prone areas in the Netherlands. Just like Grothmann and Reusswig (2006), Terpstra found a negative relation between trust and perceived flood likelihood. According to Terpstra (2011), the visibility of flood defences and the access people have to walk on dikes and dams may create a tangible impression of the reality and quality of flood-risk management. And this impression of the quality of flood-risk management could have an influence on trust. Although flood defences such as dikes are visible, it can be disputed whether people are aware of these dikes and their function. It seems obvious that this depends on the way people perceive their surroundings in general and the dikes in particular. This could also depend on the amount of (background) knowledge people have and on the way they understand the processes underlying a flood hazard.

2.2.5 Geography education and flood risk

This study is about the role knowledge plays in students' flood-risk perception. Apart from the media and the social context, formal education also plays a role in acquiring knowledge and the formation of beliefs with respect to flood risk. In the geography course books, which are used by all students who have participated in this study (van den Berg, 2003; van den Berg, 2008), flooding in the Netherlands is one of the themes. Table 2.1 shows the themes related to flooding in the Netherlands in these course books. It makes clear that attention is mainly paid to the causes of flooding and the adjustments that have been made by water boards in the past and in recent years. Hardly any attention is paid to the possibility of and the exposure to flooding as well as individual hazard adjustments. As the course books are used all over the Netherlands the focus is on hazard knowledge with respect to the Netherlands in general. The only distinction that is made is between the coastal areas and the floodplains along rivers. Apparently, there is hardly any attention to the specific local situation with respect to flooding and water safety. Although the accompanying workbooks contain some exercises and questions about the local situation, it depends on the individual teacher in terms of whether and how to deal with the subject of flooding in the local situation. Hence, we will make a difference between flood-risk perception and hazard knowledge at a national or general level and with respect to the surroundings of a school, which we call the local or personal level. One of the main geographical skills in education is the ability to describe and explain features at different scales (van den Berg, Bosschaart, Kolkman, Pauw, van der Schee, & Vankan, 2009). With respect to the understanding and evaluation of flood risk, the ability to switch the scale from a national to a local level and vice versa, is essential because it enables students to relate features at both scales. It remains to be seen whether current geography education enables students to relate both levels of scale. Sjöberg (2003) has also made the distinction between general risk (risk to others) and personal risk. According to Sjöberg, many studies, mainly with respect to lifestyle risks, have shown that personal risks are judged as smaller than general risks. From both a pedagogical and a psychological position, it is important to understand the way students perceive the risk at both levels.

The main aim of geography in secondary education is the acquisition of knowledge and understanding about a broad variety of themes, including the formation of the Dutch landscape and flood hazards in Netherlands. With respect to flood hazards, raising students' risk perception is just an implicit goal of geography education. In this process the individual teacher plays an important role. Therefore, students' beliefs as well as the flood-risk perception of teachers will play a role in this study. It is a relevant question to ask what flood-risk perception teachers have and to what extent teachers influence students' flood-risk perception.

According to Ronan et al. (2010), just a few studies have focused on the effects of hazard education programs on risk perception and preparedness of students. Moreover, these studies focus particularly on students' knowledge of hazard responses (Ronan, Johnston, Daly, & Fairley, 2001; Ronan & Johnston, 2001; Ronan et al., 2010). This may be an adequate approach in the situation of New Zealand (Ronan et al. 2001, p.2), where students have 'reasonably accurate risk perceptions'. But in the Dutch situation, where students, just like adults (Terpstra, 2011), are supposed to have weak risk perceptions and where there is no explicit hazard education program, we intend to explore to what extent background knowledge of flood hazards and water management has an effect on risk perception.

Table 2.1 Flood-related subjects and types of hazard knowledge in the course books used (van den Berg, 2003, 2008)

Secondary education	Flood-related subjects	Type of hazard knowledge	Number of lessons in the course books
First year 12/13-year-old students	Flooding along the coast and rivers in the Netherlands in historical perspective.	- Genesis - Adjustments by national water board	3
Second year 13/14-year-old students	Polders and water management in the lower parts of the Netherlands	- Adjustment by water boards	2
Third year 14/15-year-old students	Water management and water safety along the coast and the rivers, including current measures	- Genesis - Adjustments by water boards	4

2.2.6 Aims and hypotheses

In this study, we try to explore the role of knowledge in the formation of students' personal flood-risk perception. In order to interpret the supposed relations, we explore the level of knowledge students actually have as well as students' risk perceptions. Because both cognitive and affective factors influence flood-risk perception, in addition to knowledge, the perception of environmental cues, perceived fear and trust in flood protection are also part of this study. Figure 2.1 shows our model, which is based on the dual-process theory (Loewenstein et al., 2001; Slovic et al., 2004), PADM (Lindell & Perry, 2004) and the risk perception model by Renn and Rohrmann (2000).

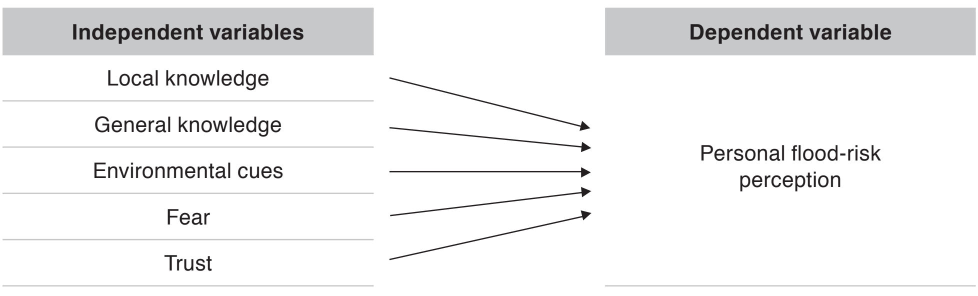

Figure 2.1 Model of flood-risk perception.

The main research question is: *What is the role of knowledge in the formation of personal flood-risk perception among 15-year-old students in the Netherlands?* In order to answer this question we will explore the descriptive research questions[1] RQ1 up to RQ4 and the inferential research question RQ5.

RQ1: *What level of knowledge do 15-year-old students actually have with respect to flood hazards and water management?*

RQ2: *How do 15-year-old students perceive general and personal flood risk?*
On the basis of previous studies we expect that:
H1: the perception of general flood exposure among 15-year-old students in the lower parts of the Netherlands would be stronger than their perception of personal flood exposure.

RQ3: *What are the differences in flood-risk perception between students in the lower parts and the higher parts of the Netherlands?*

RQ4: *To what extent do students' and geography teachers' flood-risk perceptions correspond?*

RQ5: *To what extent do knowledge, environmental cues, fear and trust influence flood-risk perception?*
On the basis of previous studies we expect that:
H2: there would be a positive relation between local knowledge and personal flood-risk perception.
H3: there would be a positive relation between general knowledge and personal flood-risk perception.
H4: there would be a positive relation between fear and personal flood-risk perception.
H5: there would be a negative relation between trust and personal flood-risk perception.
H6: there would be a positive relation between environmental cues and personal flood-risk perception.

[1] These research questions contribute to answering the sub-questions 1 and 2 on page 32. The formulation of the research questions deviates slightly from the sub-questions 1 and 2 on page 32. This is due to the fact that this chapter was published as a standalone scientific journal article.

2.3 Method

This study aims for the development of knowledge about the way secondary school geography could play a role in raising students' flood-risk awareness in the Netherlands. In order to explore students' beliefs about flood risk and their level of knowledge of flooding, an online questionnaire and an online knowledge test have been compiled. The questionnaire and the knowledge test were discussed with three geography teachers and three experts on water management. Also, two authors of the geography course book assessed the knowledge tests. The questionnaire and knowledge test were pretested among 60 students in the same age group and school level as the target group.

2.3.1 Research group

In 2010, 483 15-year-old students at the pre-university education level (VWO) and senior general secondary education level (HAVO) participated in this study. Those students came from 11 secondary schools in various flood-prone areas. These flood-prone areas comprise the regions below sea level as well as the floodplains of Rhine and Meuse. Although this group of 11 schools is widely distributed over the Netherlands, it does not completely represent all the flood-prone areas. Schools from the northern region are missing. Additionally, 134 students from 3 schools on the higher ground in the Netherlands, with the exception of the floodplains of the rivers Rhine and Meuse, acted as a reference group (Figure 2.2). In the higher parts of the Netherlands, there is no threat of flooding from the sea or the main rivers. On the other hand, there can be some inconvenience after a short period of heavy rain. Initially, 28 schools from different flood-prone areas and from the higher ground, all using the same series of geography course books, were approached to participate in this study. Eventually, 14 schools were prepared to participate. An average of 44 students per school participated in groups ranging from 20 to 70 students.

In the continuation of this study we distinguish students from the lower Netherlands and the higher Netherlands. In this study the designation "lower Netherlands" comprises the flood-prone areas below sea level as well as the floodplains of Rhine and Meuse which lie above sea level. The designation "higher Netherlands" concerns the areas above sea level with the exception of the floodplains of Rhine and Meuse. A group of teachers acted as a reference group. Fifty geography teachers completed the questionnaire with respect to flood-risk perception.

Figure 2.2 Participating schools in the Netherlands
(● flood-prone areas; ○ higher ground).

These teachers came from 12 schools in various flood-prone areas. Initially, 65 teachers were approached and eventually 50 participated. Fifty percent of this group of teachers came from schools that also participated with their students.

The whole group of 617 participants consisted of 15-year-old students who were at the end of their third and last year of junior secondary education. All students in the research group used the same series of course books (van den Berg, 2003; van den Berg, 2008) within the framework of their geography lessons. At all participating schools, geography is a compulsory subject in the first three years of secondary education. On the other hand, the number of periods spent on geography is not legally defined. It may differ between one and two lessons per week, and it may differ per year. Of the 617 students, 49% are female. The gender distribution between the groups from the lower and higher Netherlands differs ($\chi^2(1) = 5.68$, $p = .017$). For both the higher Netherlands and the lower Netherlands, there are significant differences between boys and girls with respect to a few risk-perception variables.

2.3.2 Measurements: risk perception

With respect to students' beliefs about flood-risk perception and risk-related aspects, students were asked to judge a series of 18 statements on a 5-point scale (1 = disagree completely, 2 = disagree partly, 3 = partly agree/partly disagree, 4 = partly agree, and 5 = agree completely). Perceived flood exposure was measured with respect to the surroundings of the school (personal level, 2 items) and with respect to the Netherlands in general (general level, 2 items). Besides, the variable flood consequences was measured and based on 5 items. Furthermore, the questionnaire measured perceived fear with statements about the amount of perceived worry, fear and panic while thinking of flood hazards. Trust in flood protection was measured as the trust in protection and expertise of flood-risk management with respect to the surroundings of the school. The perception of environmental cues was measured with statements about the extent to which students are aware of stormy weather, high water levels and parental information about flooding in the past. For each variable, the mean was calculated as the average of the items within the scales.

In order to determine the predictors of flood-risk perception personal flood-risk perception was computed as a conjoint measurement (Grothmann & Reusswig, 2006; Terpstra & Lindell, 2012) of perceived personal flood exposure and perceived consequences by multiplying both variables. This means that personal flood-risk perception is highest when both the perception of exposure and the perception of the consequences are high.

2.3.3 Measurements: knowledge

The knowledge test in this study consists of two parts. The first part comprises knowledge with respect to the Netherlands in general (general knowledge) and is a reflection of the contents of the geography course books that are used by all students. The questions are related to hazard genesis, hazard adjustments and water management. The second part of the knowledge test is about knowledge with respect to the school surroundings (local knowledge). These questions reflect the questions in the first part with respect to the Netherlands in general and have been converted to the local level. Besides hazard genesis, hazard adjustments and water management, a question with respect to hazard exposure is also included. Furthermore, these questions with respect to the school surroundings are a combination of indirect knowledge (what is learned in classroom) and knowledge based on personal experience in the surroundings of the school. Because of the differences in school surroundings, the correct answers differed per school. The correct answers were determined on the basis of an online digital height file (www.ahn.nl), the online risk map of the Netherlands (www.risicokaart.nl) and topographical maps.

The knowledge test as a whole consists of 10 multiple-choice questions and 15 questions in which students have been asked to judge whether the statements are either true or untrue. Each question includes the option "don't know". In order to be able to compare the results for each category of knowledge, the correct answers were totalized and converted to a scale of 1 to 10. The mark 10 means that all questions are correct. In order to validate the knowledge test, three geography teachers and two authors of the geography course book assessed the tests. The questions with respect to both general and local knowledge are shown in appendix A.

2.3.4 Analysis

To obtain adequate measures for the six constructs of interest, a principal component analysis (PCA) was conducted on the 18 items of the questionnaire. As the resulting factors might be correlated, the PCA was run with oblique rotation. The internal consistency of each resulting scale was measured using Cronbach's α. For personal and general flood exposure, the Pearson correlations between the items are reported as well, as these two constructs were measured by two items only.

To investigate the exploratory research questions, and to test the hypotheses, various descriptive and inferential statistical techniques were used, as described below. To explore the differences in flood-risk perception and knowledge between 15-year-old students in the higher and lower parts of the Netherlands, a MANOVA was performed in SPSS. Because the gender distributions differed between the 2 samples, we controlled for gender. According to hypothesis 1, it would be expected for students in the lower parts of the Netherlands, that their perceived flood exposure for the Netherlands in general would be higher than with respect to the school surroundings. This was tested by measuring whether the difference between perceived flood exposure for the Netherlands and perceived flood exposure for the school surrounding was equal to zero.

To test hypotheses 2–5, regression models were set up separately for the higher and the lower parts of the Netherlands. Flood-risk perception was used as the dependent variable, and knowledge about the Netherlands and the surroundings, perception of environmental cues, trust, perceived fear, and gender were used as the independent variables. Regression coefficients, because of the correlation between independent variables, do not always do justice to the actual importance of each independent variable, so correlation coefficients are presented as well (Courville & Thompson, 2001). All analyses were performed using SPSS 20.

2.4 Results

2.4.1 Principal component analysis

Table 2.2 shows items and factor loadings. The results confirm the intended factor structure and show that there were no cross-loadings.

2.4.2 Flood-risk perception and knowledge

The descriptive research questions RQ1 up to RQ3 concern the level of knowledge and risk perceptions among 15-year-old students in the higher and lower Netherlands. In order to find out whether students in the higher Netherlands think differently from students in the lower Netherlands we performed a MANOVA in SPSS, controlling for gender. The MANOVA was significant ($F(8, 607) = 12.35$, $p < .001$). Table 2.3 indicates that there are significant differences between students in the higher and lower Netherlands, with respect to most risk variables.

The first research question (RQ1) concerns knowledge. The level of knowledge students have is low. On average, students are able to answer 50% of the knowledge questions correctly. This applies to both general and local knowledge. Bivariate correlations show that general and local knowledge are related (Pearson correlation $r = .458$, $p < .001$). Students who know more of one category of knowledge also have a higher level of knowledge of the other category. Since the geography course books focus on general knowledge, we may conclude that the effectiveness of geography education is not very high. It is not clear whether the level of local knowledge should be ascribed to geography lessons or whether it should be considered that local knowledge is acquired independently. After all, local knowledge is not dealt with in the geography course books. Whether a student is in the position to acquire local knowledge depends on the individual teacher, the students' ability to relate hazard features from a general to a local level and other sources.

The second and third research question (RQ2 and RQ3) examine the risk perceptions among 15-year-old students and the differences between the lower and higher Netherlands. The perception of personal flood exposure (Table 2.3) is significantly higher among students in the flood-prone areas (mean 2.09) than among students in the higher parts (mean 1.34). This difference appears logical because the higher parts of the Netherlands are not threatened by flooding. It makes clear that there is some awareness of the chance of flooding among students in the flood-prone areas. With respect to the lower Netherlands, students' perception of flood exposure for the Netherlands in general is higher than with respect to the school surroundings. The difference between both variables is 1.08 (Table 2.3), which is significantly higher than zero ($t=8.00$, $p < .001$). This is in support of hypothesis 1. Students' awareness of flood exposure concerning the Netherlands in general, is much higher than with respect to students' school surroundings. It could mean that students tend to think that flooding in the Netherlands is imaginable but at the same time they perceive that flooding in their surroundings is highly unlikely. With respect to students in the higher ground, the difference between general and personal flood exposure is logical because there is no threat of flooding in the higher ground. Perceived fear is low, and there is no difference in fear between the students from the flood-prone areas and the higher ground. Trust in flood protection is high, and the perception of environmental cues is low.

The fourth research question (RQ4) concerns the flood-risk perceptions of 15-year-old students and teachers in the flood-prone areas. Teachers' perception of personal flood exposure (students: 2.09; teachers: 3.31) and general flood exposure (students: 3.17; teachers: 4.26) is considerably higher. To a lesser extent this also applies to flood consequences. Of course, this difference may be due to teachers' professional training and the way they are focused on this subject. But it is clear that despite geography education, students in the flood-prone areas think differently than their teachers.

2.4.3 Predictors of flood-risk perception

The inferential question (RQ5) concerns the relationships that knowledge, perception of environmental cues, fear and trust have with students' flood-risk percep-

Table 2.2 Factor pattern coefficients for exploratory factor analysis with oblique rotation of flood-risk perception scales (N=617).

Items	1*	2*	3*	4*	5*	6*
1. I think the surroundings of my school could be hit by flooding.	**-.77**	.06	.13	.12	.11	.00
2. I think the surroundings of my school could be hit by flooding in the coming year.	**-.67**	.11	.05	.14	-.08	.16
3. I think the Netherlands could be hit by flooding.	-.11	**.78**	.06	-.06	.16	-.12
4. I think the Netherlands could be hit by flooding in the coming year.	.02	**.84**	-.03	.05	-.11	.08
5. If the school surroundings would be hit by flooding, I think the roads would be damaged heavily.	-.13	-.12	**.79**	-.07	-.04	-.05
6. If the school surroundings would be hit by flooding, I think houses would be damaged.	-.14	-.05	**.78**	-.03	.08	-.17
7. If the school surroundings would be hit by flooding, I think daily life would be disturbed for a long time.	.19	.11	**.76**	.10	.05	.03
8. If the school surroundings would be hit by flooding, I think there will be many deadly victims.	.04	.10	**.69**	.02	-.08	.17
9. If the school surroundings would be hit by flooding, I think my family and I would end up in a life-threatening situation.	-.01	.08	**.67**	-.01	-.04	.24
10. I have experienced dangerous high water levels in the surroundings of the school.	.13	.08	-.01	**.85**	-.05	-.06
11. I heard my parents talk about dangerous high water levels in the surroundings of the school.	-.09	-.02	-.05	**.78**	-.01	-.04
12. I can remember a heavy storm in the surroundings of my school.	-.20	-.09	.05	**.61**	.05	.09
13. I think that water managers in the surroundings of the school are able to predict water levels well.	-.08	.02	-.07	-.04	**.89**	-.00
14. I think that the dikes in the surroundings of the school are maintained well by the water managers.	-.12	.05	.01	-.05	**.88**	.02

15. I think that the surroundings of the school are protected well against flooding.	.33	-.05	.07	.12	**.56**	.03
16. Thoughts about flooding in my own surroundings make me feel anxious.	-.01	-.03	.01	-.03	.01	**.94**
17. Thoughts about flooding in my own surroundings panic me.	-.00	-.02	-.01	-.00	-.02	**.92**
18. Thoughts about flooding in my surroundings make me feel worried.	-.06	.02	.04	-.01	.06	**.85**
Eigenvalues	1.80	1.74	3.42	1.98	2.09	3.01
Cronbach's α	0.63	0.56	0.82	0.64	0.69	0.90
Pearson correlation	.49**	.39**				

Note: pattern coefficients over .40 appear in bold
*1 Perceived personal flood exposure, 2 Perceived general flood exposure,
3 Perceived flood consequences, 4 Perception of environmental cues,
5 Trust in flood safety, 6 Perceived fear
**$p < .01$

tion. Table 2.4 shows the predictors of risk perception among 15-year-old students in the flood-prone areas (lower Netherlands) and with respect to the higher ground (higher Netherlands) where the threat of flooding does not exist. In this part of the study, we have made use of the conjoint measurement of risk perception. With respect to the lower and the higher Netherlands, the model fits the data well (lower Netherlands: Wald $F (5,5) = 91.26$, $p < .001$; higher Netherlands: $F (6, 127) = 6.305$, $p < .001$).

As far as the flood-prone areas are concerned, the results make clear that local knowledge plays a role in the formation of personal flood-risk perception among students (β=.23, $p < .001$, in support of H2). Both the bivariate correlation and the regression analysis show that general knowledge does not play a role in personal flood-risk perception which is not in support of H3 (β= -.05, ns). Furthermore, the results support hypotheses 4 and 6. Perceived fear has the largest effect on flood-risk perception (β= .33, $p < .001$). The perception of environmental cues has a distinct effect (β= .14, $p < .01$). Trust (H5), just like gender, has no effect on flood-risk perception (β= -.08). With regard to the higher ground there is no significant relation between both categories of knowledge and flood-risk perception. Although there is no threat of flooding on the higher ground, fear and environmental cues have a positive effect on flood-risk perception.

Table 2.3 Means and standard deviations of flood-risk perception, risk-related variables (5-point scale) and knowledge (10-point scale) among 15-year-old students and teachers.

	Lower Netherlands		Higher Netherlands		Teachers in the lower NetherlandsN=50	
	15-year-old students N=483		15-year-old students N=134			
	mean	SD	mean	SD	mean	SD
Perceived personal flood exposure	2.09	1.06	1.34***	0.74	3.31	0.83
Perceived general flood exposure	3.17	1.01	2.82**	1.02	4.26	0.62
Perceived flood consequences	3.15	0.95	2.66***	1.08	3.64	0.87
Perception of environmental cues	1.78	0.93	1.50*	0.74		
Trust in flood protection	3.74	0.90	3.29***	1.12		
Perceived fear	2.05	1.12	2.13	1.18		
General knowledge	4.96	2.28	3.78***	2.34		
Local knowledge	4.86	1.96	5.09	2.18		

Risk-related variables are measured on a scale from 1 to 5; knowledge-related variables are measured on a scale from 1 to 10. Significant differences between students in the lower and higher Netherlands are indicated with asterisks in the higher Netherlands column (*p < .05, **p < .01, ***p < .001).

2.5 Conclusions and discussion

Until now, there has been hardly any study of students' flood-risk perception. Therefore, this study aims to explore students' flood-risk perception in the Dutch flood-prone areas and to explore the role of knowledge in the formation of flood-risk perception. The students' level of knowledge with respect to flood hazards and water management is low. This could have to do with the contents of geog-

Table 2.4 Predictors of flood-risk perception.

	Lower Netherlands N=483		Higher Netherlands N=134	
	Personal flood-risk perception		Personal flood-risk perception	
	r	β	r	β
General knowledge	.06	-.05	-.18	-.06
Local knowledge	.23**	.23***	-.25*	-.12
Perception of environmental cues	.24***	.14**	.36***	.30***
Trust in flood protection	-.08	-.08	.09	.06
Perceived fear	.36***	.33***	.31***	.26**
Gender (female)		-.02		-.02
Explained variance (R^2)		.20		.23

r = Pearson correlation coefficient; β = standardized regression coefficient,
*p < .05, **p < .01, ***p < .001

raphy education during the first three years of secondary education. The course books that are used by all participating students only pay attention to hazard knowledge in general and emphasize the hazard adjustments by the water boards. No attention is paid to the local situation in the surroundings of each school, and there is no information about the possibility of flooding and the exposure to flooding water. It is very well possible that the lack of these facts and circumstances make this topic less meaningful to students. This could lead to limited knowledge retention.

The results also show that, with respect to students in the lower Netherlands, the perception of flood exposure in the surroundings of the school is low. Although students' perceptions of flood exposure in the Netherlands indicate that they have the opinion that the Netherlands could be hit by flooding, they can hardly imagine that their own surroundings could be flooded. This is in agreement with Slovic, Fischhoff, and Lichtenstein (1981), who postulated that people see themselves as immune to hazards. Also, Weinstein (1989) described the optimistic bias with respect to personal risk in comparative risk judgment, which should be applicable to diverse hazards. Moreover, he suggested that optimism is greatest for low-probability hazards with which people lack any personal experience, which is applicable to flood hazards. The well-known phenomenon "It won't happen to me" is also applicable to perceived flood exposure among Dutch 15-year-old students.

The results show that perceived fear is low, trust in flood protection is high, and the perceived consequences of flooding are moderate. This corresponds more or less with the results of Terpstra (2011), who studied flood-risk perception in three different flood-prone areas in the Netherlands among adults. This correspondence is notable because of the differences in the location of the areas, the items used and the age of the participants. Apparently, there seems to be hardly any difference between adults' and adolescents' flood-risk perception. This is in agreement with Millstein and Halpern-Felsher (2002), who concluded that adolescents do not show stronger feelings of invulnerability than adults.

Compared to students in the lower Netherlands, students in the higher Netherlands think differently about flood risk. Their perceptions of flood exposure, flood consequences and environmental cues are significantly lower than among students in the lower Netherlands, which is logical, given the fact that there is no threat of flooding in the higher Netherlands.

Geography teachers play a role in raising students' flood-risk perception. Although geography teachers have higher flood risk perceptions than their students, they do not succeed in raising the level of students' risk perception. There are different reasons for this. Firstly, it has to do with the content of the geography course books, as mentioned before. Secondly, there are no legal prescriptions with respect to the curriculum and flood hazards in geography education. Improving students' flood-risk perception is an implicit goal of geography education when dealing with natural hazards. The extent to which teachers tend to focus on this subject will differ, especially with respect to the surroundings of the school and the students' personal situation. Thirdly, as described by Terpstra (2011), flood-risk management in the Netherlands is about to change from a primarily prevention-based approach towards a broader, proactive approach that includes peoples' awareness of the possibility of flooding in their own surroundings. This change in risk approach has not yet reached all levels of society including geography education.

The regression analysis in the current study supports the importance of local knowledge in relation to the formation of flood-risk perception. This indicates that logical thinking based on correct knowledge influences flood risk perception. General knowledge of flood hazards and water management does not show this relation. Botzen et al. (2009) also found a positive relation between knowledge and flood-risk perception in a study among adults in the Netherlands. A comparison with our results is difficult because Botzen et al. limited knowledge to the causes of flood events, and it is unclear in their study to what level of scale this type of knowledge is related. Furthermore, the regression analysis shows that perceived fear has the largest effect on flood-risk perception. Also, in the reference group for the higher ground without the threat of flooding, fear has a positive effect on flood-risk perception. It seems plausible to conclude that the lack of worries (perceived fear) along with the low level of local knowledge explains the low risk perceptions among students in the flood-prone areas.

According to Siegrist and Cvetkovich (2000), people who lack knowledge of hazards rely on trust when making judgments of risks. Our results show that, in general, trust in flood protection is high and knowledge of flood hazards is low. However, the regression analysis in our study does not show convincing results. Trust in flood protection has no significant effect on flood-risk perception. This differs from other studies in which a negative relation between trust and flood-risk perception was found (Grothmann & Reusswig, 2006; Terpstra, 2011). These different results may be caused by differences in the used measures. Grothmann and Reusswig (2006) found a negative relation between trust and protection motivation while Terpstra determined a negative relation between trust and perceived flood likelihood. On the other hand, we measured the relation between trust and risk perception in which risk perception was defined as the conjoint measurement of perceived flood exposure and flood consequences. Terpstra has assumed that trust is not only influenced by affect but also by logical thinking. Because of the visibility of the quality of flood defences, this should influence trust. Further study is needed to determine by what factors trust is influenced.

The results show that students with a higher perception of environmental cues also have higher risk perceptions. Because this variable has to do with the extent to which students remember stormy weather and high water levels, it seems logical to assume that these remembrances influence both cognitive and affective evaluations of flood risk. The regression analysis shows that both affective and cognitive factors influence flood-risk perception. This is in agreement with research that shows that risk judgment is the result of an integrated effect (Slovic et al., 2004). Since both categories of knowledge - general and local - consist of only twelve closed-ended questions each, it is necessary to further investigate the role of knowledge. Apart from that, further understanding of the processes and circumstances that precede a flood should be explored.

Future studies

Since the results show that students' level of knowledge with respect to flood hazards and water management is low and because local knowledge has a positive influence on flood-risk perception, it is necessary to do further research on this subject. This will involve misconceptions and the understanding of flood risks in local surroundings. Furthermore, it is important to have better insight as to what students know of flooding in the past and the way they relate this to flood risk in the future. At the same time, it is necessary to make clear to government institutions that the current situation - in which any author of geography course books is free to decide whether and to what extent hazard education will be part of the curriculum - is inadequate. The educational authorities should have a coherent view on why and how to raise flood-risk perception in general and with respect to geography education in particular. Many authors have emphasized the effect of previous experience with hazards on risk perception in general and on flood risk perception in particular (Grothmann & Reusswig, 2006; Siegrist & Gutscher, 2006; Terpstra, 2011). Further research is needed to determine the role of direct and vicarious flood experiences in the formation of risk perception among adolescents.

Finally, further research is needed to study what methods are required in geography education to impove students' knowledge and understanding of water management and flooding as it relates to their local areas and to what extent this will lead to an increased awareness of vulnerability with respect to possible flooding. In accordance with Terpstra (2011), we suggest that both affective and cognitive factors should play a role in the research into such educational methods.

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

"I think that you get in such a panic that you don't quite know what to do, unless you know beforehand that it's going to happen."