Masterthesis

The impact of prior attitudes and prior knowledge on the problem formulation stage of information problem solving.

Gerdo J. Velthorst

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Begeleiders: Prof. dr. F.L.J.M. Brand-Gruwel and J. Frerejean, PhD
Examinator: Prof. dr. H.P.A. Boshuizen
Studentnummer: 850659995
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Abstract

Information problem solving (IPS) with the purpose of learning is common practice in higher education. Most of the information problems students engage in can be characterized as ill-defined. The first and pivotal step in solving these types of information problems constitutes the formulation of a problem statement that reflects an understanding of the essential characteristics of the information problem. Descriptive models of the IPS-process emphasize the importance of this first stage. Research has shown that individuals differ in solving information problems. Limited prior knowledge impedes a thorough IPS-process, and IPS is prone to bias due to prior attitudes. However, most studies do not take problem statement formulation into account and primarily study bias in the selection of information with artificial search engine result pages. The aim of this study was to determine the impact of prior knowledge and prior attitudes on the first stage of IPS, problem formulation, considering a wider range of information seeking activities.

Seventy freshmen pre-service teachers were given an ill-defined information problem regarding the controversial issue of climate change. Students were asked to make preparations for writing an informative article. After a short period of online information searching to explore the topic, students formulated an essential question, provisional answer and selected four useful sources. The result on these tasks was considered to be a problem statement. A logging tool recorded information searching unobtrusively and students were asked to take notes. Ten days before, students were questioned about their attitudes towards the topic at hand. Analysis of the information seeking activities in the first stage of IPS showed that participants demonstrate bias in information seeking, consistent with prior attitudes. Most consistency was found in the keywords students used to search for information and to a lesser extent in the follow-up activities: the essential questions, provisional answers and selection of information. Attitude strength explained the relationship between prior attitudes and bias in information seeking only in the keywords and central questions. Participants with stronger attitudes demonstrated less consistency and participants with weaker attitudes demonstrated more consistency of prior attitudes with bias in information seeking. These results show that prior attitudes and the strength of these attitudes affect the first stage of information problem solving. When using ill-defined information problems in higher education, educators should be aware that students are not unbiased when they engage in these problems. As a result of prior attitudes, intended learning outcomes may be out of reach right from the start. Regulatory activities that address prior attitudes have to be part of information problem solving.

Keywords: higher education, information problem solving, problem formulation, prior attitudes, prior knowledge, attitude strength.
3. Introduction

In most contemporary educational programs in higher education, students work on assignments that at some point involve working on information problems. The availability of the Internet in education has considerably changed the process of information seeking. Nowadays students’ information seeking activities are almost always mediated by the World Wide Web. The purpose of information seeking in higher education is not just to retrieve information or to find the right answer, but to engage in information seeking for learning. The information seeking behaviour aimed for in these tasks exceeds fact-finding and requires investigative activities in a more exploratory manner (Marchionini, 2006). Students are expected to adopt an information seeking approach in which they analyse and scrutinize information to deepen their understanding of a particular topic (Bowler, 2010; Limberg, 1999). In practice however, students appear to gather facts from the start, rather than use information to organise ideas and reflect upon them (Kulthau, 2004; Todd, 2006).

Learning from information problems is not only pertinent at the end when students have all the information they need, but also during the information seeking process, particularly in the initial stages of the information seeking process as described by Kuhlthau (2004). In these stages, students first explore their information problem. Often, they experience uncertainty because they operate on the limits of their understanding and the boundaries of the topic are yet to be discovered (Anderson, 2006). While exploring, students’ thoughts develop, resulting in a clear, concise and well-structured information problem statement, which is the starting point for further collection and use of information. At this point, as a result of learning, students’ problem statements should reflect a deeper understanding of the topic and the task at hand (Attfield, Blandford, & Dowel, 2003). The extent to which problem statements are well-structured and concise determine the success and efficiency of forthcoming information seeking activities (Kulthau, 2004; Marchionini & White, 2007). A significant part of working on information problems should therefore be devoted to thinking and learning in the initial stages (Todd, 2003). Learners do not always perceive the importance of activities that lead to a clear problem statement and often expect to be able to express focus right from the start (Isbell & Kamerlocher, 1998).

Most process models of information seeking acknowledge the importance and complexities of the initial stages of information seeking (Brand-Gruwel, Wopereis, & Walraven, 2009; Kuhlthau, 2004; Marchionini, 1997; Sutcliffe & Ennis, 1998). Research efforts have led to increasing refinement of these models by clarifying cognitive attributes that account for individual differences in information seeking. It is clear that prior knowledge and prior attitudes influence information seeking (Hart et al., 2009); information seeking is prone to ignorance and bias. Most research on prior knowledge and attitudes, though, is primarily devoted to the post-focus stage of information seeking. It stands to
reason, however, that bias in information seeking originates earlier, in the early pre-focus stages of information seeking where students engage in exploratory activities and construct their problem statement. The purpose of this study is to determine the impact that prior attitudes toward the topic of an information problem and prior topic knowledge have on this initial stage of information seeking. The results may be useful for educators responsible for tutoring students working on information-based tasks or writing task descriptions for information based assignments.

3.1 Information problem solving

Information seeking behaviour is concerned with the methods people employ to discover and gain access to information in order to satisfy a goal (Marchionini, 1997; Spink & Cole, 2004; Wilson, 1999; Wilson, 2000). Information seeking is common in professional practice, and often embedded in a wider set of actions or a larger process of task completion (Saracevic et al., 1988; Spink & Cole, 2006; Vakkari, 1997). In accordance with the seminal work by Dervin and Nilan (1986), the information seeker can be seen as an active agent in finding and using information. Moreover, individuals vary considerably in the information seeking behaviour they demonstrate (Ingwersen & Järvelin, 2005). Information seeking is a complex process encompassing a wide variety of information seeking activities and corresponding behaviours. This becomes clear when information seeking is perceived as problem solving.

Information problem solving can be seen as a particular instance of problem solving, dealing with information problems. Information problems are problems or problem situations that can be resolved by gathering and using information (Brand-Gruwel, Wopereis, & Vermetten, 2005; Case, 2012). There are several problem-solving methods tailored for solving information problems, for example the Information Search Process model (Kuhlthau, 2004), the Big6 model (Eisenberg, 2008) and IPS-I model (Brand-Gruwel, Wopereis, & Walraven, 2009). Although these models identify different stages, this does not imply that information problem solving is a linear process (Foster, 2006; Foster & Urquhart, 2012). The different stages and activities are highly interrelated, the outcomes of each activity depend on the outcomes of adjacent activities, and each activity requires an intelligent coordination of cognitive skills (Brand-Gruwel, Wopereis, & Vermetten, 2005; Hill, 1999; Moore, 1995; Wilson, 1999).

Most information problems students work on in higher education can be characterised as ill-defined, because tasks are open-ended, task descriptions are poorly specified or afford multiple interpretations, and when used for learning, students start as novices with regard to the topic at hand. Therefore, these information problems cannot be solved in an obvious and straightforward manner (Anderson, 1993; Chi & Glaser, 1985; Jonassen, 2000; Mayer & Wittrock, 2006; Shuell, 1990; Simon, 1973; Simon, 1978). Problem definition is a prerequisite first step for solving these ill-defined
information problems (Byström & Järvelin, 1995; Vakkari, 1999). That is, students first need to identify, understand and represent the essential characteristics of the information problem, thoughtful structure the problem elements, and plan the problem solving process (Chi & Glaser, 1985; Marchionini, 1997; Ormerod, 2005; Wopereis, Brand-Gruwel, & Vermetten, 2008).

Constructing a problem definition of information problems is done by performing several tasks (Brand-Gruwel, Wopereis, & Walraven, 2009). Performing these tasks results in a comprehensive, inclusive and concise description of the information problem, with the use of relevant and differentiated concepts in an integrated fashion (Vakkari, 2000). A first task, after reading the task description, is to express the information need in essential and subsidiary questions (Brand-Gruwel, Wopereis, & Vermetten, 2005; Taylor, 1962). These questions set the first boundaries of the problem space and reflect prior subject knowledge. A second task is to construct an expectation of what the answer will, by and large, look like (Marchionini, 1997). A third task is to derive the information requirements: ‘What information do I need?’ These requirements relate to the type and amount of information needed and the relevance criteria to judge the information found. A problem definition resulting from these tasks provides a clear sense of direction that guides further information seeking activities (Kuhlthau, 2004).

3.2 Prior attitudes and prior knowledge
There is little doubt about the importance of the initial stage of information problem solving. But the extent of our understanding of the cognitive processes involved in the first stage of information problem solving is limited. It is important to note that each stage in information problem solving yields its own information seeking behaviour. Vakkari and Hakala (2000), for example, found that in the pre-focus stage students, writing their master’s thesis, reject specific document types like literature reviews and conference papers because these types of information contain very specific information. Instead, students look for general background information, for example in encyclopaedias, which give a helicopter view of the topic. In the following stages of information problem solving, when a high degree of focus is attained, students look for more faceted background information, information that is situated in subtopics of the general topic (Vakkari, 2000). A specific focus on the different stages in information problem solving is therefore warranted.

Prior attitudes and information seeking. People bring their own views with them when solving an information problem. When a search strategy is adopted, these views are visible in the keywords people use, the particular links that are followed in a search engine result page, and even in the reasons why people search for information. For example, White (2013) found that when people are questioned in retrospect about their beliefs before and after searching for the answer to a self-generated yes-no
question, the majority of the people have the goal of confirming their prior-held belief, finding yes for an answer, and reaffirming their initial answer when engaging in multiple results. After searching, beliefs appear to be even stronger. In spite of the amount and the diversity of online information, information seeking behaviour is not open-minded and free from bias.

Research on decision making shows that decision makers who engage in information seeking have tendencies to look up information consistent with or in support of their preliminary choice of decision and give more positive evaluations to confirmatory information (Fisher & Greitemeyer, 2010). This phenomenon is known as confirmatory information seeking and is most pronounced in situations where decision makers sequentially seek pieces of information (Jonas, Schulz-Hardt, Frey, & Thelen, 2001). In these situations, decision makers remind themselves repeatedly of their preliminary choice in every information seeking event. Consequently, decision makers suffer from selective exposure to information consistent with their preliminary choice.

Generally speaking, people tend to be biased in favour of their own arguments and judge confirming views as more persuasive and convincing. This not only holds true for simple fact-finding tasks or preliminary decisions, but also for prior attitudes regarding the topic at hand. Attitudes concerning particular objects or thoughts consist of evaluations with a cognitive component and an affective component (Bohner & Dickel, 2011; Kronick, Judd, & Wittenbrink, 2005). The cognitive component is based on the ideas, beliefs and perceptions about an object. The affective component is based on the preference and feelings toward an object. Attitudes may differ in the degree to which the cognitive or the affective component is dominant (Azjen, 2001; Crano & Prislin, 2006). Therefore, aside from attitude extremity – the degree to which an idea or belief deviates from the mid-point of a continuum like favour-oppose – attitudes can also be described in terms of attitude strength (see for example Brannon, Tagler, & Eagly, 2007).

Most research on attitudinal preferences in information seeking concentrates on one particular information seeking activity, the selection of information. Hart et al. (2009) confirm in their meta-analysis that people, across studies, demonstrate a moderate confirmation bias in information selection; people prefer attitude-consistent information. This is explained mostly by defence motives, which is the desire to defend one’s prior attitude. Confirmation bias is larger when people have high commitment and attach personal relevance to their attitudes. Confirmation bias is smaller when people have high confidence in their attitudes, because in that case people believe in their capacity to effectively deal with inconsistent information.

In a study regarding political issues like gun ownership, Knobloch-Westerwick and Meng (2009) show that students, as expected, are more likely to choose information consistent with their attitudes and spent more time with consistent information. With decreasing certainty students choose inconsistent information more often and spend less time reading consistent information. Their
exploration is that people with uncertain attitudes expect to gain more certainty in their point of view when looking into inconsistent information, as briefly as they do. Brannon, Tagler, and Eagly (2007) also demonstrate that psychology students’ strength of prior attitude, a composite measure that includes importance and certainty, predicts the preference for attitudinally consistent information. When students were asked to choose sources from a list of titles, similar to search engine result pages, increasing strength of prior attitudes leads to increasing preference for attitude consistent information.

Findings concerning the impact of strength-related characteristics of prior attitudes on information seeking are not conclusive and depend on which combinations of strength dimensions are used and how relationships between these characteristics are conceptualized. For example, Sawicki et al. (2011) found that only when undergraduate students are not familiar with the information presented, decreasing levels of attitude confidence - when students are uncertain about their attitudes as the authors express it - lead to increasing bias aligned with prior attitudes. The explanation is that unfamiliar and consistent information helps to ascertain views founded on weak attitudes and therefore might be processed more actively. This is in line with Hart et al. (2009). For students that report familiarity with the presented information, it is increasing levels of attitude confidence that lead to bias toward consistency. The same relationship was found by Knobloch-Westerwick and Meng (2009) and Brannon et al. (2007).

Specifically with regard to science topics, Jang (2013) found that adults more often select news articles referring to attitude-inconsistent information and spend more time reading this information. This phenomenon was explained by schema theory, because novel or schema-inconsistent information is more salient to people. Also, the preference for challenging information is most visible when news articles discuss risks and threats. Thus, under some conditions, prior attitudes can even enforce a disconfirmation bias, where people avoid certain types of information. Further analysis shows that certainty of attitudes, which is explained as perceived science knowledge, increases the preference for attitude-consistent information.

Cognitive bias is not only visible when people select information, but also in students’ essay writing when information is processed and used (Edwards & Smith, 1996; Kobayashi, 2010). If students disagree with one of two opposing views, arguments against the opposing view in texts are engaged in and used in essay texts. Students seem to give more attention and scrutinize arguments incompatible with their attitudes whereas they uncritically accept arguments compatible with their attitudes. Students seem to put extensive cognitive effort in defending their position by disconfirming or negating incompatible arguments when they are asked to take a stance in their writings.

Van Strien, Brand-Gruwel, and Boshuizen (2014) found that secondary school students take views consistent with prior attitudes in their essays. Students were given time to read multiple texts with conflicting views about violent videogames, and afterward students were given an open-ended
essay writing task. Students with neutral prior attitudes were compared to students with positive attitudes toward the issue. They found that students with neutral prior attitudes were more likely to reflect a balanced view in their writings and summarize information at hand. Students with positive prior attitudes were considerably more likely to take a positive view consistent with their attitudes and to base their writings on personally added information.

**Prior knowledge and information seeking.** Aside from differences in prior attitudes, students’ prior knowledge and understanding also varies. Some students may have initial ideas about the topic under investigation and can detail rich concept maps of their prior knowledge with a high number of concepts and relationships, whereas others may not (Chung & Neuman, 2007). Prior knowledge can be defined as the whole of declarative (‘knowing that’) and procedural knowledge (‘knowing how’), structured in schemata, which a person has available when starting a task. Prior knowledge can be described in quantitative and qualitative qualities: completeness, amount, accuracy (or misconceptions), accessibility, availability, and structure (Dochy, Segers, & Buehl, 1999). Information seeking is complicated when students are domain novices with limited prior knowledge, which is often the case in education. Specifying the information problem, or even constructing queries for that matter, in domain specific keywords that are not known and describing what information is needed are difficult tasks (Belkin, 2000).

Willoughby et al. (2009) compared the quality of essays written by students with high and low prior domain knowledge that were evenly distributed to a thirty minute search and no-search condition, prior to writing. Students with high prior knowledge that were allowed to search the Internet outperformed students with high prior knowledge who were not allowed to search the Internet. The scores of the latter group were comparable to those of students with low prior knowledge, with or without internet exposure. It appears, then, that the value of information searching for learning is only visible for students with high prior knowledge.

High levels of prior knowledge, next to system expertise, differentiate successful from less successful searchers, because topic knowledge contributes to the relevance and precision of using keywords and keyword combinations, finding the information needed on a webpage and the evaluation of information (Belkin, 2000; Makinster, Beghetto, & Plucker, 2002). Shiri and Revie (2003) found that people with a moderate or high topic familiarity are slightly (but not significant) more involved in the conceptual analysis of terms or documents, in the information found. They also use system features of the search environment more often. When the information seeker is familiar with the subject, he extracts more (additional) terms from the information that is found. These additional terms subsequently lead to highly useful information sources when used in search engines, because these terms reflect the words and language used in those documents to be found (Pennanen &
Vakkari, 2003). Broader search terms are dropped – i.e. the information seeker becomes more selective – and an increasingly larger and specific vocabulary is used. This facilitates the use of more specific search terms and greater query specificity.

Regarding prior knowledge, a review study of Chen and Macredie (2010) shows that domain novices differ from experts in their capacity to process online information. Novices benefit from hierarchical text structure, hierarchical maps and conceptual overviews to browse through hypertexts, because they lack a conceptual schema to map onto the information. Also, domain novices use fewer (meta)cognitive strategies and spend less time with these strategies while searching. With the exception of fact-finding tasks, novices need more time and actions to find the information and deal with information problems differently.

Low levels of prior topic knowledge evoke data-driven strategies where information seeking is broad and superficial (Land & Greene, 2000). At the very beginning of discovering topic ideas data-driven exploration is fruitful, but strategies have to become goal-directed where the information problem is focused and information is consciously judged in light of project goals, hypotheses and information needs. When data-driven strategies consolidate, topic understanding remains fragmented and most of the learning time is spent on undirected searches for information.

The knowledge base of prior attitudes. Prior knowledge and attitudes are also related, because attitudes are embedded in knowledge structures. When these structures are extensive and well-organized, they can foster strong attitudes toward an attitude object. Wood, Rhodes, and Biek (2014) reason that in case of high prior knowledge, the strength of affect moderates preference for attitude consistent information. When affect is strong, positive or negative, information processing is selective and more attention is given to attitudinal consistent information. When affect is moderate or low, an elaborated knowledge base leads to open-mindedness and enhanced capacity to process new information. Knowledgeable people, they found, are more capable of recalling counter-attitudinal information and evaluating information critically. Low prior knowledge induces closed-mindedness, because new information cannot be processed adequately. In combination with moderate or low affect, information is more likely to be processed in accordance to prior attitudes because the effort that is invested in information processing is likely to be minimal.

3.3 Research questions and hypotheses
In summary, it is evident that prior attitudes and prior knowledge affect information problem solving. As suggested by Smith Fabrigar, and Norris (2008), processing information consistent with prior attitudes toward the topic of an information problem might even be a common strategy when information is abundantly available and people have to be selective. This is the case when people can
use the Internet for solving information problems. There appears to be a paucity of research of the impact of prior attitudes on particular stages of the information problem solving process. We argue that from the start of information problem solving, bias could exert its influence. The present study tries to fill this gap and addresses the question to what extent problem formulation, and the corresponding information seeking activities, is influenced by prior attitudes and whether attitude strength can explain differences between participants in the degree of consistency of bias in information seeking with prior attitudes.

First, it was expected that participants demonstrate bias in all the information seeking activities regarding problem formulation, consistent with their prior attitudes. Second, we hypothesized that consistency of bias in information seeking with prior attitudes is higher in the first information seeking activity (searching for information), compared to consistency in the remaining information seeking activities (the selection and use of the information found). Third, it was expected that attitude strength accounted for differences in consistency scores between participants. We assumed that, in line with Sawicki et al. (2011), participants were relatively unfamiliar with the information that would be found. Therefore, when controlling for prior knowledge, participants with weaker prior attitudes were expected to demonstrate bias that was more consistent with prior attitudes in all information seeking activities, and participants with stronger prior attitudes were expected to demonstrate bias less consistent with their prior attitudes.

4. Method

4.1 Participants
All participants were first-year pre-service teachers of one Dutch teacher training institute. After four years of higher education, qualified teachers teach all subjects to children between four and twelve years of age in primary education. A total of 70 participants took part in this study (23 men, 47 women; M_{age} = 18.99 years, SD = 1.53). Because this study was embedded in a mandatory course, all first-year students participated. All students were Dutch speaking and started with their second semester of the first year.

4.2 Materials
Search task. Participants were given an ill-defined information problem. All participants received the following task description: ‘You were asked by the editors of National Geographic magazine to write a two-page article about the causes of climate change. You are completely free to elaborate on your own ideas. Because you do not have time to speak with experts, you will have to find your information on the Internet. You have decided to take fifteen minutes to explore this topic on the Internet. That
will help you to come up with a focused question that you find interesting for the article and that you are going to answer later on with the information you can find on the Internet. After exploring the topic, you will first share your ideas with the editors.

**Task environment.** All participants worked individually on a work station: a desk with a personal computer with the operating system Windows 7 and a 19” monitor. The screen resolution was set on 1280 x 1024 pixels per inch. The Internet browser Firefox was used, version 24.0.

### 4.3 Measures

**Prior attitudes.** Prior attitudes were measured with one paper-and-pencil-questionnaire. The questionnaire served two goals: participant selection and determination of prior attitudes.

**Participant selection.** Only those participants who actually acknowledged the issue of climate change were included in this study, because participants’ stance in the controversy regarding the causes of climate change (natural vs. anthropological causes) was used to investigate bias. Seven items questioned participants’ beliefs about the existence of climate change, for example: ‘I don’t believe the earth is warming up’. Participants rated their agreement with these items on a 7-point Likert scale ranging from completely disagree to completely agree. Total scale reliability was high but should be interpreted with caution, because of high inter-item correlation of three item pairs ($\alpha = .80$, $r$ ranging from .55 to .62). The scores on the seven items were averaged to produce a composite measure. Participants with mean scores equal or above scale mid-point, were included.

**Prior attitudes.** Two self-report scales assessed attitude *position* and attitude *strength*. First, attitude *position* was measured with four items regarding two related controversies. Two items questioned participants about their position in the controversy about causes of climate change. The first item emphasised anthropological causes and the other item natural causes: ‘Humans are responsible for the earth warming up’ and ‘Climate change is a natural phenomenon’. The other two items questioned participants’ beliefs about the scientific evidence regarding climate change: “There is enough scientific evidence to warrant the claim that man is responsible for climate change” and “There are only few scientists who truly believe that our climate is changing due to anthropological causes”. Principal component analysis confirmed that the items measured two distinct controversies, explaining 68% of the variance. Next, for each item pair a proposition score was calculated. By subtracting participants’ position with regard to the natural stance from the position toward the anthropological stance, an attitude position score toward the proposition ‘climate change is caused by man’ was calculated. The attitude position score, ranging from -6 to 6, was rescaled to 0 to 1, with stepwise increments of 1/12. On this recoded scale a 0 reflected complete disagreement, 0.5 reflected a neutral attitude position, and 1 complete agreement with the proposition.
Second, attitude *strength* was measured with a 6-items 7-point Likert scale. The dimensions that were taken into account are *importance*, *certainty*, *interest* and *ego-involvement*. The items were derived from previous research by Brannon, Tagler, and Eagly (2007) and Pomerantz et al. (1995). *Importance* is operationalized with the statement ‘Climate change is an important issue for me’. *Certainty* is operationalized with the statements ‘My opinions of climate change are not likely to change’ and ‘I am sure that my opinions about climate change are right. *Interest in relevant information* is operationalized with the statement ‘I am interested in information about the issue of climate change’ and *Ego-involvement* is measured with two statements: ‘My opinions of climate change are representative of my values’ and ‘My opinions of climate change are central to my self-image’ (Pomerantz et al., 1995). The items of the prior attitude strength measure were subjected to principal components analysis, which confirmed the presence of a one-factor-structure, explaining 56% of variance and with factor loadings ranging from .52 to .82. Scale reliability was high ($\alpha = .84$), but should be interpreted with caution, because of high inter-item correlation of four item pairs ($r$ ranging from .53 to .67).

**Bias measures information seeking activities.** The participants undertook four information seeking activities. After *information searching*, participants were asked to use the information found to formulate a central *question* for their article, a provisional *answer* and participants selected four useful online *sources*. Each activity was assessed for the presence of bias, and therefore four bias measures were established.

Bias in *information searching* was evaluated by looking at the queries within a search session. Each query was judged as neutral or biased toward natural or anthropological causes. Only queries with the keywords ‘human’ and ‘natural’, corresponding synonyms or direct searches into specific anthropological or natural causes were judged as biased. For example, the queries ‘causes climate change humans’ and ‘fossil fuels climate change’ were judged as queries biased in favour of anthropological causes. Queries like ‘causes climate change’ and ‘enhanced greenhouse effect’ were judged as neutral. Next, time spent within each query was taken into account. This was done by the following formula: $0.5 + 0.5 \times (p_{\text{time } \text{anthro}} - p_{\text{time } \text{natural}})$, where $p_{\text{time}}$ is the proportion of time spent within a biased query relative to time spent within all queries. This resulted in a continuous scale, with bias scores ranging from 0 to 1. For example, a score of 0.5 reflected a neutral session. In this case, the participant only spent time within neutral queries or an equal amount of time was spent within anthropological and natural biased queries.

Bias in participants’ *questions* was evaluated by assigning one of three ratings to each question. A rating of 0.5 was assigned to questions that reflected a neutral position, 0 to biased questions toward natural causes and 1 to a biased question toward anthropological causes. Questions
could not be scored if they only reflected consequences of climate change, for example ‘What can we do to reduce the effects of climate change’. In addition, all questions were divided under two independent subject matter specialists. A short scoring guideline with three examples were given. The subject matter specialists were also asked to mark the questions they could not score. Agreement, including agreement on questions that could not be scored, was substantial, $\kappa = .611$ (95% CI, .437 to .785), $p < .000$. If inter-rater agreement was only computed based on questions that could be scored, then 47 cases were included and $\kappa$ increased to .720 (95% CI, .489 to .951), $p < .000$.

Bias in participants’ answers was evaluated by assigning one of three ratings to each answer. A rating of 0.5 was assigned to answers that reflected a neutral position, 0 to biased answers toward natural causes and 1 to a biased answer toward anthropological causes. In addition, all answers were divided under two independent subject matter specialists. A short scoring guideline with three examples were given. There was substantial agreement between the two judgments, $\kappa = .683$ (95% CI, .489 to .877), $p < .000$.

Bias in participants’ selection of online sources was evaluated by rating the content of listed webpages. Each webpage was examined by intuitive content analysis and a rating of 0.5 was assigned to webpages that reflected a neutral position, 0 to biased pages toward natural causes and 1 to biased webpages toward anthropological causes. Websites that predominantly engaged in anthropological or natural causes were judged as biased. Bias meant that a website was selective to one viewpoint with regard to the causes of climate change. A website was judged neutral when no outspoken viewpoint was presented or both viewpoints were equally presented. Next, time spent on each page was taken into account. This was done by the following formula: $0.5 + 0.5 \times (p_{\text{time, anthropo}} - p_{\text{time, natural}})$, where $p_{\text{time}}$ is the proportion of time spent on a webpage relative to time spent within all selected pages. This resulted in a continuous scale, with bias scores ranging from 0 to 1. For example, a score of 0.5 reflected a neutral selection. In this case, the participant only spent time on neutral webpages or an equal amount of time was spent within anthropological and natural biased webpages.

**Consistency with attitude position.** Finally, four consistency scores were calculated by relating participants’ (prior) attitude position to the bias found in each of the information seeking activities. Because both attitude position and all four bias measures were projected on a 0-1 scale, consistency was calculated by the following formula: $1 - |$ attitude position – bias in information seeking activity $|$. The consistency scores reflected the degree of consistency of attitude position with bias found in the information seeking activities, where 0 reflected no consistency and 1 reflected maximum consistency.

Consistency scores were interpreted within these two extremities. Consistency of prior attitudes with bias in information seeking was viewed as less evident in the low range from 0 to 0.50 and more evident in the high range from 0.50 to 1. Instead of pursuing scale analysis, the theoretical
mean was chosen to establish these ranges because attitude position was measured with neutral items, an odd-length Likert-scale was used, and bias measures were established by either calculation or judgements corroborated by a subject matter specialist.

**Prior knowledge.** Different methods exist for assessing prior knowledge. Association tests and free recall tests are two of these methods. Although association and free recall tests are less objective in comparison with multiple choice test and results are known to confound with verbal abilities, they are widely used because these tests afford in-depth investigation of prior knowledge (Dochy, Segers, & Buehl, 1999). A combination of these methods is found in mapping techniques like mind mapping (Eppler, 2006; Hay, Kinchin, & Lygo-Baker, 2008). Mapping techniques can be used to assess the extent and, more importantly, the structure of declarative knowledge (Shavelson, Ruiz-Primo, & Wiley, 2005).

In this study, fully student-generated mind maps were used. A mind map has a ‘central image’ with main themes that radiate as branches from the central image. Mind maps are more associative and less structured than concept maps. Mind maps focus more on free concept and relationship exploration without a superimposed structure (Davies, 2010). Less directed mapping techniques are shown to elicit more higher-level thinking like content-relevant explanations of concepts and their relationships (Ruiz-Primo et al., 2001b; Shavelson, Ruiz-Primo, & Wiley, 2005).

Prior to judging the mind maps, an expert mind map was construed and validated by a subject matter teacher. The rating of mind maps was initially based on different characteristics: the number of concepts, the position of concepts in the hierarchy and the relationships between concepts (see also D’Antoni, Zipp, & Olson, 2009; Evrekli, Inel, & Balim, 2010). The quality of participants’ mind maps, however, did not afford a fine-grained scoring protocol. Also, participants were not asked to explain their mind maps and they used different central keywords (‘climate change’ and ‘causes of climate change’). A modest scoring protocol was therefore used. Only keywords or short phrases were allowed as nodes in the mind maps. With exception of the central keyword, the number of nodes in each mindmap was counted. This total score was corrected by subtracting nodes that could not be related to the expert mind map. Nodes related to consequences of climate change were marked as an example, and possible misconceptions were marked, but neither was subtracted from the corrected total score.

A random sample of 36 mind maps was scored by a second judge. A two-way mixed, absolute agreement, intra-class correlation coefficient was calculated to assess inter-rater agreement. Agreement proved to be good (single measures ICC = .882, 95% CI, .782 to .938, p < .000). Second, an indication of the accuracy of the prior knowledge assessment was established by comparing the results with the results of two National entry-level exams freshmen pre-service teachers had to take.
These tests measure subject matter knowledge on geography and science (biology and physics) and were considered to approximate prior knowledge on a more general level. A weak correlation was found for the science test, $r(57) = .34, p < .01$. A marginal correlation was found between corrected prior knowledge scores and the geography test, $r(57) = .19, p = .146$.

4.4 Procedure
This cross-sectional one shot study followed two stages: the assessment of prior attitudes and a classroom session in which students worked on an information problem.

Assessment of prior attitudes. To avoid priming effects, ten days before the information seeking session the 17-item questionnaire was administered on paper, which inquired about participants’ attitudes towards the issue of climate change and the causes of climate change. The questionnaire was handed out together with an exam students had to take. At the end of the exam, each student filled out the questionnaire. The questionnaire started with a short introduction on paper and after the questionnaire was filled out, the questionnaire was handed in and students left the classroom.

Classroom session. All participants took part in a forty minute classroom session. These sessions were scheduled in four groups of approximately 20 students. After a short word of welcome, each student was seated behind a computer an asked to work individually. The classroom session was divided in four parts, and the instruction for every part was displayed on the students’ computer screens. Participants were prompted to start and finish each of the four parts simultaneously to ensure equal time on task.

For the first part, participants were given a task description: a short story of 120 words that invited them to prepare a two-page article for a magazine about the causes of climate change. Participants read the task description on their screens. After two minutes, when every participant had finished, they were asked to proceed with the next part.

Second, participants were instructed to draw a mind map using as much of their prior knowledge about the topic climate change as possible. This task was introduced as a sensible first step. Participants were told to place ‘climate change’ in the centre of their mind map. The mind map was constructed in the digital environment Mindmaps, an open source and web-based mind mapping application. All students had practiced working with this application once in preparation of this session but did not receive training in constructing mind maps. After five minutes, students were asked to end their mind mapping activities and save their mind map.

Third, every participant was given fifteen minutes for exploratory activities with use of the Internet. Participants had been pre-alerted to the last part in which they would be asked to write down
an essential question for the article that also seemed worthwhile investigating further. Participants
could take notes. They were instructed to use Firefox as their Internet browser and were told that their
browser use was recorded. The information seeking process was recorded with recording software, a
Firefox plug-in. This plug-in recorded their browser use, use of search engines, search terms, and
browsed webpages. Hyperlinks that referred to useful information resources could be copied and
pasted in an empty, digital worksheet.

For the fourth and last part, participants were given stepwise instruction for three short
assignments. The first assignment was to write down the essential question. “Write down the main
question about the causes of climate change that you are going to answer in your paper with a search
for information on the Internet”. This question reflects the information problem statement after the
exploratory activities. The second assignment was to write down a possible answer in two or three
sentences to that question. “Write down, in three sentences, a possible answer to that question that you
will probably arrive at.” This reflects the student’s hypothesis. The third assignment was to select four
sources from the previous encountered information sources that seem worthwhile for further
investigation in light of the question posed. “Select four sources that you encountered and you
probably will use to answer the question of your paper.”

4.5 Data analysis
The first hypothesis, that participants demonstrate bias consistent with their prior attitudes in all four
information-activities, will be tested with one sample t-tests, testing the highest and lowest consistency
scores to the defined lower and upper range of consistency scores.

The second hypothesis, that consistency of prior attitudes with bias in information seeking is
most evident in information searching, in comparison to the remaining information seeking activities,
will be tested using a one way multivariate analysis of variance. The multivariate model consists of
one independent variable with four levels, representing the information seeking activities, and the
consistency scores regarding proposition 1 and 2 as dependent variables. This hypothesis will be tested
with Helmert-contrasts.

Prior to analysis, the assumptions were checked. Two univariate outliers (z = -3.72 and z = -
3.51; | z | > 3.29) and one multivariate outlier (Mahalanobis D = 21.02; D > 10.828, χ2 with df = 1, p <
.001) were removed. Only for query formulation (queries), the assumption of multivariate normality
was not met (W = 0.913, p < .001), which can reduce power. However, the sample sizes in each cell
were approximately equal and further examination of the variance-covariance matrices showed that
the assumption of homogeneity of variance was met (ratio min:max variance 1:2.4 and covariance 1:3.9).

The third hypothesis, that variance in consistency scores could be explained, when controlling
for prior knowledge, by a linear relationship between consistency and attitude strength, will be tested
using multiple regression. In this model prior knowledge and attitude strength are entered as predictor variables and, repeated for all four information seeking activities, consistency as criterion variable. With 60 respondents and two predictor variables, the number of cases was below minimal requirement of 66 (50 + 8 times 2) for testing multiple correlations with anticipated medium-size relationships ($f^2$ = .15) and substantially below the required 106 (104 + 2) for testing the individual predictors (Tabachnick & Fidell, 2013). The confidence level was set to 95%. Statistical power to detect medium-size relationship was of concern. A priori power calculation with G*Power revealed statistical power of .747 (<.80) and therefore results were considered to be a tentative exploration of relationships.

Prior to analysis, the assumptions for regression analysis were checked. For each combination of dependent and independent variables scatterplots were produced that indicated linear relationships. A restrictive decision rule was used for deletion of univariate outliers, biased toward inclusion of data ($|z| > 3.29$). Scatterplots and Mahalanobis $D$ values were used to identify outliers in the regression model and to assess discrepancy. The influence of the outliers was assessed by Cook’s $D$. Only high discrepant outliers (Mahalanobis $D$ values greater than 9.21 ($\chi^2$ distribution with df = 2, $p < .01$)) that were influential (Cook’s $D$ values greater than 1) were deleted. Identified outliers were also inspected for their impact on each of the predictors and high influential cases on predictors were deleted (standardized DFBeta’s > 1). Only one case was deleted in the regression analysis of the information seeking activities question, because it was influential on the predictor attitude strength. Both predictors were uncorrelated, $r(58) = .029$ and VIF values were acceptable. Multicollinearity was not an issue. Independence of residuals was checked with the Durbin-Watson statistic and for each regression model found to be around 2.

5. Results

A total of 70 students participated in this study. Six participants were excluded, because they did not complete two or more tasks. Also, items of the attitude questionnaire were examined prior to analysis for accuracy of data entry and missing values. Minimum and maximum values were checked and only one missing value was found. Second, only participants who acknowledged the issue of climate change were included, leaving 60 participants for further analysis.

5.1 Consistency of bias in information seeking with prior attitudes
First, it was expected that participants demonstrated bias in all four information-seeking activities, consistent with their prior attitudes. Participants’ prior attitudes were questioned by means of two propositions. For each proposition and information seeking activity, table 1 displays the mean
consistency of prior attitudes with bias demonstrated in information seeking. Consistency was expressed on a scale from 0 to 1.

A paired-sample t-test was conducted to compare consistency scores on proposition 1 with proposition 2. There was not a significant difference between the scores on proposition 1 (M = .75 SD = .19) and proposition 2 (M = .77 SD = .19); t(223) = -1.41, p = .161. These results suggest that consistency of prior attitudes with bias in information seeking, that has been made visible by means of two propositions, appeared equal. Therefore, the highest and lowest cell-mean of the four information-seeking activities in proposition 1 was used to classify consistency scores in the upper or lower range (figure 1). Most consistency was visible in participants' queries (M = .84), though significantly below scale maximum of 1 (t(59) = -9.34, p < .000). Least consistency was found in the provisional answers (M = .66), which was significantly above the lower bound of the upper range of 0.5 (t(54) = 5.71, p < .000). Consistency ranged in the upper range of the consistency scale. As expected, participants demonstrate bias in information seeking activities, consistent with their prior attitudes (hypothesis 1).

Table 1.

Descriptive Statistics Consistency of Bias in Information Seeking with Prior Attitudes

<table>
<thead>
<tr>
<th></th>
<th>Proposition 1</th>
<th></th>
<th></th>
<th>Proposition 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Information searching</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queries</td>
<td>60</td>
<td>.84</td>
<td>.13</td>
<td>59</td>
<td>.83</td>
<td>.15</td>
</tr>
<tr>
<td>Using the information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questions</td>
<td>52</td>
<td>.77</td>
<td>.21</td>
<td>52</td>
<td>.79</td>
<td>.20</td>
</tr>
<tr>
<td>Answers</td>
<td>55</td>
<td>.66</td>
<td>.21</td>
<td>54</td>
<td>.72</td>
<td>.22</td>
</tr>
<tr>
<td>Sources</td>
<td>60</td>
<td>.72</td>
<td>.20</td>
<td>59</td>
<td>.73</td>
<td>.17</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>.75</td>
<td>.19</td>
<td></td>
<td>.77</td>
<td>.19</td>
</tr>
</tbody>
</table>

*Note.* Consistency scores ranged from no consistency to maximum consistency (0-1)
Second, consistency of bias in information seeking with prior attitudes was expected to be higher in the first information seeking activity, when participants search for information, compared to consistency in the remaining information seeking activities that entail the selection and use of the information found. In order to examine this difference, a multivariate analysis of variance was conducted. The analysis showed that the degree of consistency differed with respect to the four information seeking tasks (Pillai’s $T = .139$, $F(6,424) = 5.269$, $p < .001$). Approximately 6.9% of the variance in the degree of consistency is associated with the information seeking activities. In a follow-up analysis, the results of the between-subject test indicated that the consistency scores differed within each proposition ($F(3, 212)$, $p < 0.001$, $\eta^2 = .117$ and $F(3, 212)$, $p <0.01$, $\eta^2 = .078$).

A planned comparison with Helmert contrasts was used to assess the difference between the consistency scores of the first information seeking activity, query formulation, with the other information seeking activities. The results showed, for both propositions, that bias in information seeking was more consistent with prior attitudes in query formulation, the first information seeking activity, compared to consistency in the remaining information seeking activities (95% CI, .057 to .163, $p < 0.01$ and .037 to .142, $p < 0.01$). Generally speaking, bias in information seeking is most consistent with prior attitudes when searching for information and to a lesser extent in the information seeking activities after information searching (hypothesis 2).
5.2 The relationship between consistency and attitude strength

We assumed that the degree of consistency of bias in information seeking with prior attitudes was influenced by attitude strength; a linear relationship was expected. When controlling for prior knowledge, participants with weaker prior attitudes were expected to demonstrate bias that was more consistent with prior attitudes and participants with stronger prior attitudes were expected to demonstrate bias less consistent with prior attitudes.

Queries. Participants were given the task to engage in exploratory information searching activities. Before analysis, an auxiliary description of the search sessions was made. Session duration was fifteen minutes and each session was recorded in a search log. A search log can be described through session, query, and term level analysis (Jansen, 2006; Jansen, 2009).

On average, recorded session duration was 14 minutes and 26 seconds. A session started on first browser interaction and stopped when participants were instructed to stop. A total of 396 queries were run with exclusion of moving back and forth from the search engine result page and session length, the number of queries per searcher that was built, was 5.58 (SD = 3.58). Participants were instructed to use Google as their search engine, but in 9.60% of the queries other search engines like Google Scholar were used.

Query analysis showed that participants build 145 unique queries. High usage queries were klimaatverandering (climate change; 58 times), oorzaken klimaatverandering (causes climate change; 58 times), broeikaseffect (greenhouse effect; 15 times), gevolgen klimaatverandering (consequences climate change; 14 times), and natuurlijke oorzaken klimaatverandering (natural causes climate change; 14 times). Participants started with 17 unique initial queries. The most occurring initial queries were oorzaken klimaatverandering (causes climate change; 22 times), klimaatverandering (climate change; 19 times), de oorzaken van klimaatverandering (the causes of climate change; 6 times), oorzaken van klimaatverandering (causes of climate change; 4 times), and klimaatveranderingen (climate changes; 4 times). Term analysis showed that participants together used 861 terms in their queries, from which 134 unique terms. High usage terms were klimaatverandering (climate change; 250 times), oorzaken (causes; 125 times), broeikaseffect (greenhouse effect; 30 times), gevolgen (consequences; 23 times) and opwarming (warming; 19 times).

A standard multiple linear regression was performed between consistency as the dependent variable and prior knowledge and attitude strength as independent variables (Table 2). For proposition 1, the results of the regression indicated the two predictors explained 8.6% of the variance ($R^2_{adj} = .054$, $F(2,57) = 2.69$, $p = .077$). It was found that attitude strength accounted for a significant proportion of the variance in consistency, after controlling for the effect of prior knowledge, $R^2$ change
= .084, \( F(1, 57) = 5.256, p < .05 \). Attitude strength was a significant predictor of consistency (\( \beta = -2.90, t(57) = -2.29, p < .05 \)). For proposition 2 the results of the regression indicated the two predictors explained 14.7\% of the variance (\( R^2_{adj} = .116, F(2, 56) = 4.816, p = .012 \)). It was found that attitude strength accounted for a significant proportion of the variance in consistency, after controlling for the effect of prior knowledge, \( R^2 \) change = .146, \( F(1, 56) = 9.571, p < .01 \). Attitude strength was a significant predictor of consistency (\( \beta = -.382, t(56) = -3.094, p < .01 \)).

Table 2.

Results Regression Analysis – Queries

<table>
<thead>
<tr>
<th></th>
<th>Proposition 1 (N = 60)</th>
<th>Proposition 2 (N = 59)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-Order ( r )</td>
<td>Z-O ( r )</td>
</tr>
<tr>
<td></td>
<td>PKN</td>
<td>ATS</td>
</tr>
<tr>
<td>Attitude strength (ATS)</td>
<td>-.289</td>
<td>-.290*</td>
</tr>
<tr>
<td>Prior knowledge (PKN)</td>
<td>.029</td>
<td>.045</td>
</tr>
<tr>
<td>Mean</td>
<td>9.40</td>
<td>3.78</td>
</tr>
<tr>
<td>SD</td>
<td>4.00</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Note: * \( p < .05 \) and ** \( p < .01 \); Consistency scores (CON) based on statement set 1 after transformation

As expected, these results suggested that attitude strength was associated with consistency. Bias in information searching was consistent with prior attitudes, but consistency was higher for participants that hold weaker attitudes and lower for participants that hold stronger attitudes. In proposition 2, an even more pronounced influence of attitude strength was visible (hypothesis 3). Figure 2 displays consistency scores used in the regression analysis for both propositions in relation to attitude strength. Due to ceiling effects, results of the regression analysis should be interpreted with caution.
Figure 2.

*Plot of the Relationship between Consistency and Attitude Strength for IS-activity Queries*

**Questions.** A standard multiple linear regression was performed between bias consistency as the dependent variable and prior knowledge and attitude strength as independent variables (Table 3). For proposition 1 the results of the regression indicated the two predictors explained 3.1% of the variance ($R^2_{adj} = -.009$, $F(2,48) = .776$, $p = .466$). It was found that attitude strength accounted for a significant proportion of the variance in consistency, after controlling for the effect of prior knowledge, $R^2_{change} = .028$, $F(1, 48) = 1.402$, $p < .05$. Attitude strength was only a marginal predictor of consistency ($\beta = -.018$, $t(48) = -1.18$, $p = .242$). For proposition 2 the results of the regression indicated the two predictors explained 11.4% of the variance ($R^2_{adj} = .076$, $F(2,47) = 3.021$, $p = .058$). Results should be interpreted with caution because of mild heteroskedasticity (bow-tie shaped; variance of residuals decreases as $\hat{y}$ increases). It was found that attitude strength accounted for a significant proportion of the variance in consistency, after controlling for the effect of prior knowledge, $R^2_{change} = .097$, $F(1, 47) = 5.072$, $p < .05$. Attitude strength was a significant predictor of consistency ($\beta = -.310$, $t(47) = -2.25$, $p < .05$).
Table 3.

**Results Regression Analysis – Questions**

<table>
<thead>
<tr>
<th></th>
<th>Proposition 1 (N = 51)</th>
<th></th>
<th></th>
<th>Proposition 2 (N = 50)</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-Order r</td>
<td>β</td>
<td>sr²</td>
<td>Z-O r</td>
<td>β</td>
</tr>
<tr>
<td></td>
<td>PKN</td>
<td>ATS</td>
<td>CON</td>
<td></td>
<td>PKN</td>
</tr>
<tr>
<td>Attitude strength (ATS)</td>
<td>-.167</td>
<td>-.018</td>
<td>.028</td>
<td>-.168</td>
<td>-.312*</td>
</tr>
<tr>
<td>Prior knowledge (PKN)</td>
<td>.076</td>
<td>-.055</td>
<td>-.002</td>
<td>.003</td>
<td>-.059</td>
</tr>
<tr>
<td>Intercept</td>
<td>.925</td>
<td></td>
<td></td>
<td>.948</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.47</td>
<td>3.67</td>
<td>.841</td>
<td></td>
<td>.851</td>
</tr>
<tr>
<td>SD</td>
<td>3.89</td>
<td>1.04</td>
<td>.114</td>
<td></td>
<td>.118</td>
</tr>
</tbody>
</table>

Note: *p < .05 and **p < .01; Consistency scores (CON) based on statement set 1 and 2 after transformation;

In consistency scores, derived from proposition 1, a marginal trend was found for attitude strength, with a slope similar to the regression line in the first information seeking activity. However, in proposition 2 the influence of attitude strength was pronounced. Bias in essential questions was consistent with prior attitudes, and attitude strength partially explained differences in participants’ consistency scores in line with the expectation (hypothesis 3). Figure 3 displays consistency scores used in the regression analysis for both propositions in relation to attitude strength. Again, due to ceiling effects, results of the regression analysis should be interpreted with caution.

Figure 3.

**Plot of the Relationship between Consistency and Attitude Strength for IS-activity Questions**
Provisional answers. A standard multiple linear regression was performed between consistency as the dependent variable and prior knowledge and attitude strength as independent variables (Table 4). For proposition 1, the results of the regression indicated the two predictors explained 3.4% of the variance ($R^2_{adj} = -.003, F(2,52) = .921, p = .404$). It was found that attitude strength did not explain the variance in consistency, after controlling for the effect of prior knowledge, $R^2_{change} = .001, F(1, 52) = .046, p = .832$. Attitude strength did not influence consistency scores ($\beta = -.029, t(52) = -.214, p = .832$). For proposition 2, linearity of the relationship between consistency scores and attitude strength is doubtful (Figure 4). The regression indicated the two predictors explained 0.9% of the variance ($R^2_{adj} = -.029, F(2,51) = .236, p = .791$). It was found that attitude strength did not explain the variance in consistency, after controlling for the effect of prior knowledge, $R^2 = .000, F(1, 51) = .000, p = .998$. Attitude strength did not influence consistency scores ($\beta = .000, t(51) = -.003, p = .998$).

Results should be interpreted with caution, because common transformations did not lead to a normal distribution of residuals.

Table 4.

Results Regression Analysis – Answers

<table>
<thead>
<tr>
<th></th>
<th>Proposition 1 (N = 55)</th>
<th></th>
<th>Proposition 2 (N = 54)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero-Order r</td>
<td></td>
<td>Zero-Order r</td>
</tr>
</tbody>
</table>
|                      | PKN  ATS  CON         | $\beta$  $sr^2$  $b$ | PKN  CON  ATS  CON  CON | $\beta$  $sr^2$  $b$
| Attitude strength (ATS) | -.029  -.029  .000   | -.005  .002  .000  .000 | .002  .000  .000  .000 |
| Prior knowledge (PKN) | .001  -.183  -.183  -.033 | -.010  -.096  -.096  -.005 | Intercept = .773  Intercept = .772 |
| Mean                 | 9.22  3.78  .662 |                      | .722                   |
| SD                   | 3.90  1.16  .211 | $R^2 = .034$ | .216 | $R^2 = .009$ |

Bias in provisional answers was consistent with prior attitudes. In contrast with queries and questions, attitude strength did not explain differences in consistency scores (hypothesis 3). Prior knowledge has a notable but marginal influence. Participants with relative higher prior knowledge appeared to be inclined to formulate provisional answers that are less consistent with their prior attitudes. Figure 4 displays consistency scores based on both statement sets in relation to attitude strength.
Source selection. Participants were given the task to select four sources. Consistency of bias in sources with prior attitudes was calculated. A standard multiple linear regression was performed between consistency as the dependent variable and prior knowledge and attitude strength as independent variables (Table 5). For proposition 1, the results of the regression indicated the two predictors explained 3.3% of the variance ($R^2_{adj} = -.002$, $F(2, 56) = .951$, $p = .392$). It was found that attitude strength did not explain the variance in consistency, after controlling for the effect of prior knowledge, $R^2$ change = .025, $F(1, 56) = 1.465$, $p = .231$. Attitude strength did not influence consistency scores ($\beta = .160$, $t(56) = 1.21 p = .231$). Results should be interpreted with caution, because common transformations did not lead to a normal distribution of residuals. For proposition 2, the results of the regression indicated the two predictors explained 0.9% of the variance ($R^2_{adj} = -.026$, $F(2, 56) = .252$, $p = .778$). It was found that attitude strength did not explain the variance in consistency, after controlling for the effect of prior knowledge, $R^2$ change = .007, $F(1, 56) = 3.85$, $p = .537$. Attitude strength did not influence consistency scores ($\beta = .013$, $t(56) = .621 p = .537$).
Table 5.

**Results Regression Analysis – Source selection**

<table>
<thead>
<tr>
<th>Zero-Order r</th>
<th>Z-O r</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKN</td>
<td>ATS</td>
</tr>
<tr>
<td>Attitude strength (ATS)</td>
<td>.160</td>
</tr>
<tr>
<td>Prior knowledge (PKN)</td>
<td>.076</td>
</tr>
<tr>
<td>Intercept = .661</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.46</td>
</tr>
<tr>
<td>SD</td>
<td>4.01</td>
</tr>
</tbody>
</table>

Bias in source selection was consistent with prior attitudes. In contrast with queries and questions, but in line with answers, attitude strength did not explain differences in consistency scores (hypothesis 3). Figure 5 displays consistency scores based for both propositions in relation to attitude strength.

Figure 5.

*Plot of the Relationship between Consistency and Attitude Strength for IS-activity Sources*
6. Discussion

6.1 Conclusions
The main purpose of this study was to provide insight into the impact of prior attitudes towards and prior knowledge of the controversial topic of an information problem on the information seeking activities performed by students in higher education when defining an information problem. Students use keywords to search, find and explore online information. They then take notes, formulate central questions and develop general ideas of the answer. These activities, which are often short of duration in educational practice, result in a concise description of the information problem that guides the subsequent steps of information problem solving (Brand-Gruwel, Wopereis, & Walraven, 2009). This first stage of information problem solving was studied using an ill-defined information problem, and students were given considerable freedom in task performance.

The most important finding is that students demonstrate bias right from the start of the process of information problem solving. Students act upon their prior attitudes, even when the assignment is to make preparations for an informative journal article about a science topic like climate change. This verifies and extends the findings of Hart et al. (2009). The influence of prior attitudes is not limited to students’ selection of information; these attitudes in fact surface in all information seeking activities. When students favour a particular position, information seeking behaviour is in alignment with that particular position.

Most consistency of prior attitudes with bias in information seeking is found in the first activity, when students search for information. In the follow-up activities, when students use the information found, consistency is also visible, albeit to a lesser extent. It is possible that congruency between adjacent information seeking activities gains importance over prior attitudes when progress is made in the information seeking activities. Additional analysis shows that consistency scores decrease, but correlations between consistency scores of adjacent information seeking activities increase. These correlations exceed those between non-neighbouring information seeking activities. This finding emphasises the importance of the (cognitive) activities students engage in, bridging information searching and the follow-up activities in problem formulation.

Furthermore, the degree of consistency partially depends on the strength of prior attitudes, at least in the first two information seeking activities (queries and questions). Mediated by search engines, participants have vast amounts of information at their disposal. Those who are presumed to be unfamiliar with all the online information demonstrate information seeking behaviour increasingly consistent with their own prior attitudes, when strength of prior attitudes decreases. This finding is in resonance with Sawicki et al. (2011). In this particular constellation of low familiarity and weak prior attitudes, high consistency might be explained by students’ heightened motivations to validate their
weak attitudes. Hart et al. (2009) state in their meta-analysis that low confidence in attitudes is related to heightened defence motivations, resulting in stronger bias. On the other hand, low consistency might be explained by dissonance theory (see for example Smith et al, 2008). Students with strong attitudes might experience less dissonance when engaging in information reflecting other views and may therefore be less motivated to avoid or more motivated to open up counter-attitudinal information.

Finally, prior knowledge does not appear to have influence on the consistency between prior attitudes and bias in any of the information seeking activities. This was unexpected in two ways. First, given the argument that strong attitudes can be the result of high prior knowledge (Wood, Rhodes, & Biek, 2014), at least a moderate correlation between the two predictors was expected. This was not the case. Second, because prior knowledge impacts information seeking and processing, it was hypothesized that the moderating impact should be visible in the full range of activities related to problem formulation. Again, this was not the case.

It is doubtful that topic knowledge is of less importance in the first stage of information problem solving. The most obvious explanation comes from methodological difficulties of using mind maps to assess prior knowledge, aside from concerns over statistical power. The mind map task did not successfully elicit issue relevant prior knowledge. Most participants used ‘climate change’ as central image instead of ‘causes of climate change’, which entails that the measurement lacks precision. Irrelevant variation might be introduced because of differences in verbal fluency, which is known to confound with the assessment of prior knowledge via mind maps. Finally, the quality of most mind maps was poor. It can be argued that most participants, even participants with relatively high prior knowledge scores, have to be classified as novices with regard to the chosen topic. Considering all participants as novices, combined with the exploratory nature and short duration of the information-searching event, could explain the absence of the influence of prior knowledge.

6.2 Limitations and future research
When studying bias in information seeking while giving participants freedom in searching for information, considerable thought has to go to choosing an issue or attitude object. The degree of bias in the field of expertise, the availability of information regarding different views, and the representation of information in search engine result pages (for example, sponsored links), were not taken into account. It is very reasonable to assume that the rank position of online sources on the search engine result pages introduced bias in all four collections of consistency scores (White, 2013). In this study, students visited webpages which were predominantly presented on the first search engine result page. A strong negative skewed frequency distribution was visible when investigating rank
position of the 794 visited websites ($Mdn = 4$) and 85.6% of the hyperlinks that were followed by students was presented in the top ten positions of the search engine result page.

The second concern regards the attitude strength construct. Because the primary goal was to take the full range of information activities into account, a general measure of attitude strength was constructed. Krosnick et al. (1993) advise caution in using composite scales to measure attitude strength due to a lack of evidence for one uniform factor structure. Also, conflicting findings regarding strength related attributes of attitudes warrants a more fine-grained approach. However, scale reliability was high, and both certainty and confidence were part of the strength construct in this study.

Third, external validity is limited. This study was done in one particular teacher education college in the Netherlands. In addition to the specific population, first-year pre-service teachers, the context in which this study took place might induce a particular kind of information seeking behaviour. A global goal for the information seeking activities was given, and students had experienced in their first semester that particular types of information (and maybe even particular types of views) are valued. In addition to cognitive characteristics, these contextual variables may also explain different findings.

Finally, the results suggest a more complex relationship between attitude position, strength and knowledge. Although attitude strength and prior knowledge were not correlated, an inspection of only the 32 participants with pro-anthropological attitudes shows a positive relationship between attitude strength and prior knowledge, which is absent in both the neutral and contra-anthropological group. This is probably due to differences in accessibility of pro-anthropological information in comparison to contra-anthropological information $pur sang$. Sample size unfortunately did not afford further analysis taking specific positions into account, but participants or particular groups of participants may differ in the extent to which their attitudes are grounded in relevant topic knowledge. Future research could disclose the impact prior knowledge, differentiating between attitude positions and stages of information problem solving.

6.3 Implications

When lecturers in higher education use information problems as their pedagogical strategy, they should realise that students differ in how they engage in these problems. More specifically, students differ in their attitudes regarding the topic under investigation, and this affects information problem solving. Ample time should therefore be devoted to problem formulation, and lecturers should make their students aware of different views that might exist with regard to the topic under investigation. Fortunately, the first stage of problem formulation is suitable to be subject of classroom collaboration and discussion. When working in groups on the same (ill-defined) information problem, problem formulations can be exchanged, and as differences and cognitive bias surface they can become subject
of further inquiry. Providing insight into the pitfalls, like cognitive bias, may also render more open-mindedness. When engaging in the first stage of information problem solving, it is worthwhile to evaluate the process and results: to what extent did attitudes or particular views affect the activities that result in problem formulation? This activity can be added as a specific regulatory activity in the IPS-I model of Brand-Gruwel, Wopereis, and Walraven (2009). From practitioners’ perspective, an interesting question arises: which pedagogical interventions can effectively reduce bias?
References


