

Persuasive Technologies: A Systematic Literature Review and Application to PISA

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Abstract

Persuasive Technologies is an expansive field that covers various research areas including engineering and social sciences. This document summarizes current and historical models of information processing, persuasion and persuasive systems design in order to place other studies in the field within context. The Persuasive Systems Design Model is then selected as the most recent and comprehensive model in the field, after which a series of sample context analyses are performed using this model. The case used for these context analyses is the PISA tool. Finally, we consider the limitations and possible future work of this literature review.

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1 Introduction

In digital security, many threats and vulnerabilities exist to the confidentiality of information, as well as the integrity and availability of services. Generally speaking, the social vulnerabilities are hardest to deal with, requiring training and motivation of people that are not necessarily motivated to act in a way that is conducive to good security practices. As a possible answer to this problem, the *Personal Information Security Assistant* (PISA) tool was envisioned, helping people act in a more secure manner by advising them and/or assisting them in performing tasks that place the security of information at risk.

However, to create a tool that is sufficiently persuasive to offer a meaningful change in security practices is not a trivial task. Therefore, as part of the development of the PISA tool, a systematic literature review was performed to gather the available knowledge on persuasive technologies: technology that is designed to persuade people to do things.

The rest of this document is structured in the following way: First, the scope of the research is detailed, along with a specification of research questions to provide a focus for the literature review. After this, the methodology for the literature review is explained, to provide the reader with a degree of confidence as to the completeness of the review. The subsequent sections then cover the results of this literature review, structured as models of behavior and decision making, models of information processing and techniques/models to persuade. Finally, one of the more comprehensive models resulting from this research is applied to the PISA tool, to create an understanding of how the PISA tool could perform in its environment, as well as *what* this environment could be. The document is then concluded by summarizing conclusions, answering our research questions and noting possible future work.

2 Scope

Due to the nature of the desired results, this literature study is confined to the fields of Computer Science and Social Sciences. It is the hope of the author that, within these fields, all papers relevant to the subject matter, persuasive technologies, are found. Computer Science is included since human media interaction and interfaces are parts of this field; Social sciences because persuasion techniques are a large element in persuasive technology. The following research questions were proposed:

RQ1: *"What models and theories related to persuasive technology exist?"*

RQ2: *"Which model is most suited to assist in the design of the PISA tool as a persuasive system?"*

3 Method

3.1 Step 1: Selection of databases, keywords

7 databases were used for the initial search:

- Scopus,
- IEEE xplora,

- ACM Digital Library,
- Web of Science,
- Sciencedirect,
- Wiley Interscience.

After this selection of databases, keywords were defined for the initial query, based on the defined scope in the previous section. 8 keywords were used in the initial search:

- **HMI**: relevant to persuasive technologies as it covers the interaction with the subject,
- **Human Media Interaction**: Included as a variant on the term above,
- **Interface Design**: Included as variant to the term above,
- **Persuasion**: relevant to research since persuading subjects to use and heed the advice of the PISA tool is required to reach the ultimate goal of the PISA tool
- **Persuasive technology**: A variant on the term above
- **Security**: Included as an aside, hoping for persuasive technology research that is more specifically related to security to improve the PISA tool,
- **Psychology**: A broad term included to gather results related to behavioral research,
- **Social Engineering**: A more specific variant of the "Security" keyword.

This combination yielded 129.336 documents.

3.2 Step 2: Limiting keywords

Due to this large initial pool of findings, The search was quickly restricted to only computer science as a field, reasoning that if the results from a social sciences paper was relevant, it would come up when searching through the references of the computer science papers. Several keywords were eliminated based on (ir)relevance:

- Psychology as a secondary concept,
- Security as relevant for PISA but not user interface design/persuasion,
- HMI as something independent of persuasive power (or at least, covered by the persuasion/persuasive technology keywords),
- Human Media Interaction as a secondary form of HMI,
- Interface Design as relevant for PISA but only indirectly influencing persuasive power.

Leaving **Persuasion** and **persuasive technology** as keywords and **computer science** as domain.

This left:

- 918 documents in scopus using keywords-abstract-title;
- 5.402 results in IEEE xplore using full text & metadata, 216 with metadata only;
- 1.752 in ACM Digital Library using Title, abstract & review, 157 with abstract;

- 427 in Web of Science using Topic=(Persuasion OR “persuasive technology”), research areas = (computer science);
- 23.013 in Scimedirect using persuasion OR “persuasive technology”; 231 when limited to the journal of computers in human behavior;
- 24.429 in springerlink using persuasion OR “persuasive technology”; 2.654 when limited to computer science;
- 36.862 results in wiley interscience using persuasion OR “persuasive technology”; when limited with AND “computer science”, returns 6.065 results.

Adding all documents together and not yet excluding duplicates across databases, this resulted in 10.653 papers. Wiley interscience gives no real option of limiting to a certain application field, which explains the extremely large number of results.

3.3 Step 3: Limiting by hand

Keeping in mind the overwhelming amount of studies in the field, the search was limited to the scopus database. From these papers, more results could then be gathered to augment the existing findings, yielding a relatively complete picture of dominant models and theories. The 918 results from the previously mentioned query in scopus were cropped with the PISA project in mind. The following criteria/key concepts were used to assess the relevance based on reading the abstracts of the papers:

- persuasive systems design (general reviews, excluding single case studies)
- Sustained behaviour change (general views, excluding single case studies)
- ambient intelligence
- subconscious persuasion/ rational vs. emotional persuasion
- Agent/avatar based persuasive systems
- Gamification
- Usage of personalized profiles in persuasion
- Security & Persuasion (as an area not of immediate, but possible future interest to PISA)

Using this, The list was narrowed to 80 papers, 58 of which were available to the University of Twente.

3.4 Step 4: Classifying/prioritizing results

To create an approximate ordering in these 58 papers, these results were divided in the following categories, to read in that order:

- Context shaping information (giving models, definitions and frameworks for thinking in the field of persuasive technologies)
- Persuasive systems design papers
- Security related papers
- Sidetracks/esoteric papers that may be of some information and/or use.

The first set of papers was used to get a comprehensive view of what is regarded as persuasive technology/systems design, the second set of papers to identify how it can be used in the context of PISA. The third and fourth set are considered future work to summarize and classify. The first two categories included 35 papers.

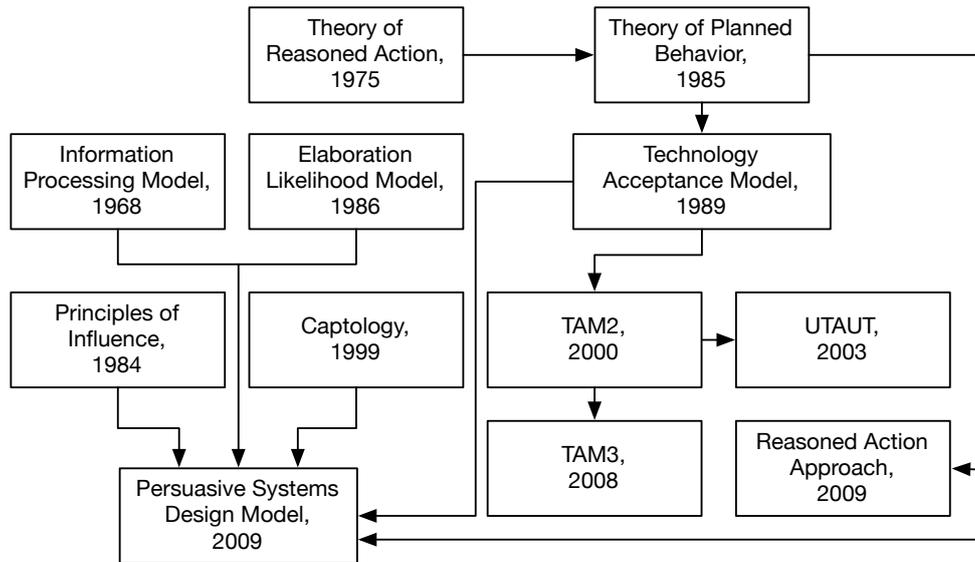


Figure 1: A historical overview of the models covered in this literature review

3.5 Step 5: Augmenting the results

After reading the papers in the first two categories, their main relevant sources were identified and retrieved, yielding a final total list of 73 papers available for perusal in the appendix at the end of this document.

4 Overview of literature

In this section, I organize and expand upon the previous work in the field, touching upon formative theories and ending with the *Reasoned Action Approach* and *Persuasive Systems Design (PSD) Model* as most recent and relevant works in the field. See figure 1 for a historical overview of the theories and models covered in this literature review. I believe the PSD model is quite thorough and solid in content due to its extensive use of previous works in the field when justifying its classification of techniques. As such, I regard the PSD model as one of the key findings of this study which can be used to guide the design of the PISA tool. I have ordered this historical overview of theories and models into three viewpoints: Subject, Message and Persuader.

4.1 Theories and models of reasoning and behavior

4.1.1 Theory of Reasoned Action/Theory of Planned Behavior

The theory of reasoned action was developed by Fishbein and Ajzen in 1975 [10] and subsequently refined in 1980 [3] and forms the one of the oldest theories in use by the Persuasive Systems Design Model below. The model finds its origin in social psychology and was conceived initially as an attempt to measure attitudes, but

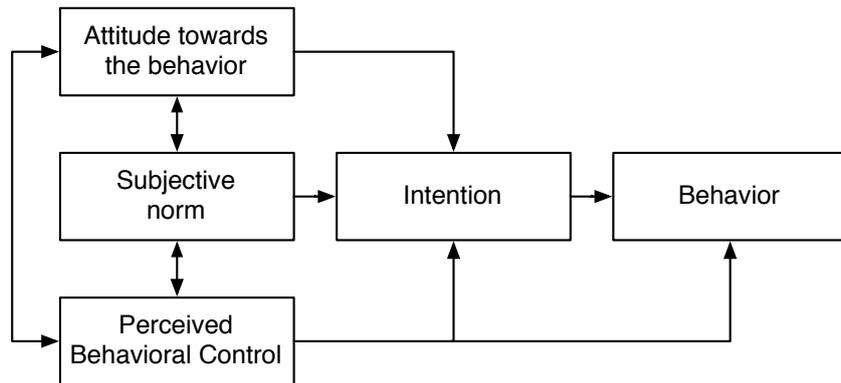


Figure 2: The Theory of Planned Behavior

was later expanded to describe how attitudes influence behavior. The initial model distinguished **attitudes** towards a behavior (the way a person sees the behavior based on previous experience or expectations) and **subjective norms** (how they think other people they care about will view this behavior). These factors lead to an intention, which in turn is translated into an actual behavior. The Theory of Reasoned Action was extended in 1985 [1] with a third dimension: perceived control. This tries to take into account the fact that not all behaviors are voluntary (or believed to be so by the subject), possibly influencing the intention. This model forms the Theory of Planned Behavior. For an overview of the model, see figure 2. The model has been a great influence on the field of social psychology and the PSD model tries to integrate these concepts in the form of persuasive techniques such as leveraging social dynamics to explain how systems can persuade. An overview of the correlations between the constructs underlying the models can be found in the Ajzen's 1991 publication[2].

4.1.2 Reasoned Action Approach

Fishbein and Ajzen have continued developing and refining their Theory of Planned Behavior. The latest version, with a book detailing the method published in 2009 [11], Refines the theory of planned behavior with several elements, dubbing it the reasoned action approach:

- Constructs are introduced which, together, form the known dimensions of Attitude, Norms and Perceived Behavioral Control (see diagram)
- Environmental factors and Skills & Abilities are two different factors in this model
- Notions of feedback loops are investigated in the book, with factors such as behaviors having a feedback loop towards beliefs about the behavior, evaluation of outcome and background factors.

The model is detailed in figure 3 . As an Illustration of the model as a decision making process, figure 4 explains how a person ends up executing a certain behavior according to this approach.

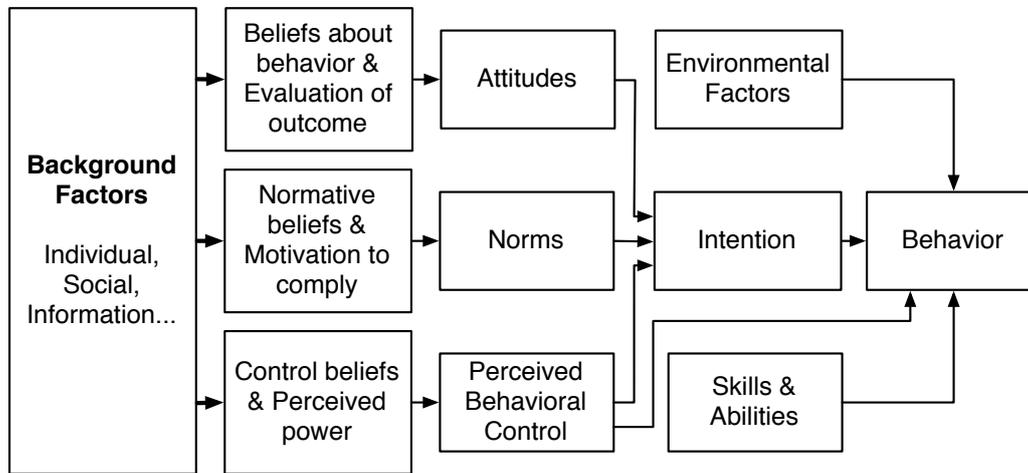


Figure 3: The Reasoned Action Approach

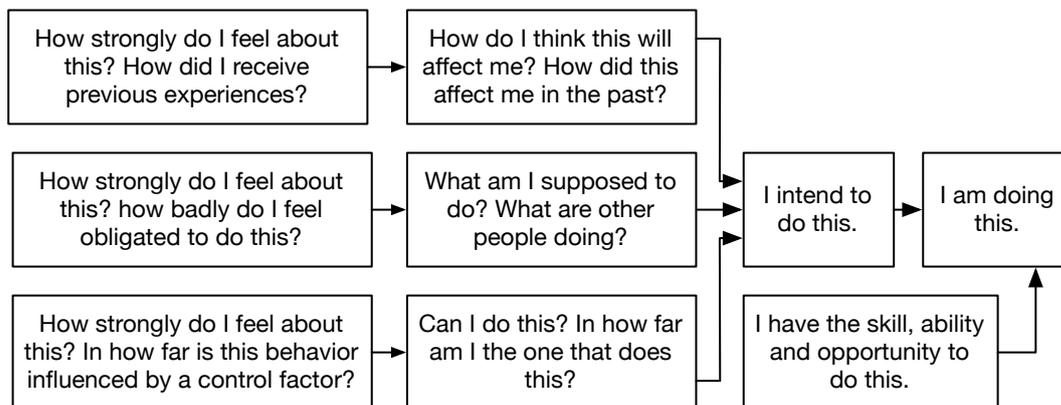


Figure 4: an instantiated version of the reasoned action approach

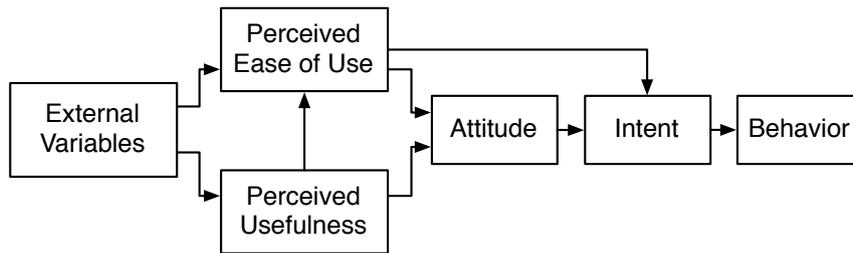


Figure 5: The Technology Acceptance Model as an extension of the Theory of Reasoned Action

4.1.3 Technology Acceptance Model

First introduced by F. Davis in 1989 [7, 8], the Technology Acceptance Model uses the Theory of Reasoned Action/Theory of Planned Behavior, postulating that the attitude dimension can be seen as consisting of Perceived usefulness and Perceived ease of use. Subsequently, the Attitude and Perceived ease of use can then be used to predict whether a user will adopt a certain new technology. One of the initial paper[7] contains lists of indicators that can be used to measure these two constructs, while the other[8] contains the diagram as portrayed in figure 5. The model was since validated by many case studies in the field. The model was extended multiple times: TAM2 [22], UTAUT [23] and most recently TAM3 [21]. TAM2 and TAM3 included many factors determining Perceived Ease of Use and Perceived Usefulness (such as Job Relevance, Result Demonstrability etc) while UTAUT replaced Perceived Usefulness and Ease of Use with 4 constructs: Performance Expectancy (how much do I believe this will help me), Effort Expectancy (How much time and effort do I need to invest to use this technology), Social Influence (what are the social pressures influencing me to adopt this technology) and Facilitating Conditions (How much does my environment support my adoption of the technology). Though the key concepts of the original TAM model are used in the Persuasive Systems Design Model, the subsequent refinements (TAM2, TAM3) and variants (UTAUT) are not mentioned or used.

4.2 Models of information processing

4.2.1 Information Processing Model

Proposed by McGuire in 1968 [17], this theory was inspired by the Yale Attitude Change Approach, which was research performed in the 1950's investigating the link between persuasive messages and attitudes. The Information Processing Model postulates that for a behavior to be changed, a persuasive message has to go through the following steps:

- Presentation: a (persuasive) message is offered to the subject,
- Attention: the user has to notice the message,
- Comprehension: the user has to understand the contents of the message,
- Acceptance: the user has to accept the contents and form the intention to act accordingly,

- Retention: the user has to remember the message contents,
- Behavior: the user has to act according to the newly formed intention.

This model is used in the PSD model in its dissection of how a system persuades: The Message is directly translatable to McGuire’s Information Processing Model. Oinas-Kukkonen and Harjumaan have noted[19] that Cialdini has criticized this way of looking at human persuasion, since it emphasizes the rational processing of arguments. According to Cialdini[6], this does not always happen: people often take ”mental shortcuts” when processing information (such as ”expensive equals good”) bypassing the message content. This concept of judging a book by its cover rather than its content can also be found as a central tenet in Petty & Cacioppo’s Elaboration Likelihood Model[20], described below.

4.2.2 The Elaboration Likelihood Model

The Elaboration Likelihood Model (ELM) was proposed by Petty & Cacioppo in 1986 [20]. It finds its origins in social psychology as a type of *dual process theory*: a theory that states that information is initially classified as (ir)relevant heuristically, after which an analytical process processes the information classified as relevant. ELM recognizes two routes of persuasion, central and peripheral:

- when a subject takes the **central route** of processing information, (s)he judges a message containing information (as in the Information Processing Model) by processing the message’s contents.
- with the **peripheral route**, the subject uses mental shortcuts to judge the message, using environmental characteristics (akin to the concept of metadata in computer science), such as the trustworthiness of the source of origin or the message’s subject.

In the Elaboration Likelihood Model, Petty and Cacioppo introduce the concept of Elaboration Likelihood: the chances of a subject taking the time to inspect (elaborate) the message’s content. They introduce the concepts ”ability” (available mental resources, distractions) and ”motivation” (relevance to subject, enjoyment of thought) to determine the probable level of elaboration that is performed on a message:

- **Ability** pertains to the subject’s available mental and physical resources such as the attention a subject can give to a message, the ability of the user to comprehend the message’s contents and/or the amount of time the user has available at that moment.
- **Motivation** is the subject’s motivation to carefully inspect the message. This is influenced by factors such as relevance to the subject (a person is more likely to look closely at something that affects him, such as salary negotiations) and/or a user’s general tendency to think about matters.

It is suggested in one of the postulates of the ELM that short term compliance is easier with the peripheral route while long term behavioral changes are best achieved by using the central route: ”When attitudes are based on high levels of elaboration, people have the necessary ”backing” to defend their attitudes against later counterattitudinal persuasion attempts and to maintain the attitude over time.

These attitudes will also tend to be more accessible and held with greater confidence. (...) Attitudes based on peripheral processes and simple cues, however, are less likely to demonstrate these characteristics.”[20]. The PSD model uses the ELM’s terminology in its identification of a system’s persuasion context: after considering the Messages a system offers to the user (Information Processing Model), it analyzes the route a system takes (ELM) when persuading users.

4.3 Theories and models of persuasion

4.3.1 Captology

According to Fogg, the term Captology was coined in 1997 at CHI '97 by a special interest group meeting[14]. It stands for *Computers as Persuasive Technologies* and is centered around the idea of a persuasive computer: *“an interactive technology that changes a person’s attitudes or behaviors”*. Over the years, Fogg has published several papers on the subject matter[14, 16, 13], as well as a book, *“Persuasive Technologies”* [12] where he expands his earlier concepts with computer credibility and the ethics of persuasive technologies. Though he has written many things about the subject matter, the most important concepts he proposes are summarized in his paper about perspectives and research directions[14]: Types of Intent and the Functional Triad.

Types of Intent Fogg states that Persuasive Technologies imply an **intent** to change an attitude or a behavior. Since computers themselves do not have any intentions, the intent to persuade a user comes from external sources. These sources fall into three categories:

- **endogenous intent** comes from the designer or producer of the system. An example would be the PISA tool, where the designers already have the intention to persuade;
- **exogenous intent** comes from the distributor of the system: if one person gives a computer technology to another with the intent to persuade, this falls under the category of exogenous intent. An example would be educational software distributed by schools;
- **autogenous intent** comes from the user itself. Examples of these would be fitness training programs that the user has started using from his/her own volition to become more fit.

These motivations are not mutually exclusive but serve to put persuasive technologies in a context.

The Functional Triad Fogg reasons that Persuasive Technologies come in three forms: as a tool, a medium or a Social actor:

- **Tools** enable and/or assist the user in performing a task. Examples of tools are calculators or word processors.
- **Mediums** convey “symbolic or sensory content” to the user. Examples are videos or simulators.

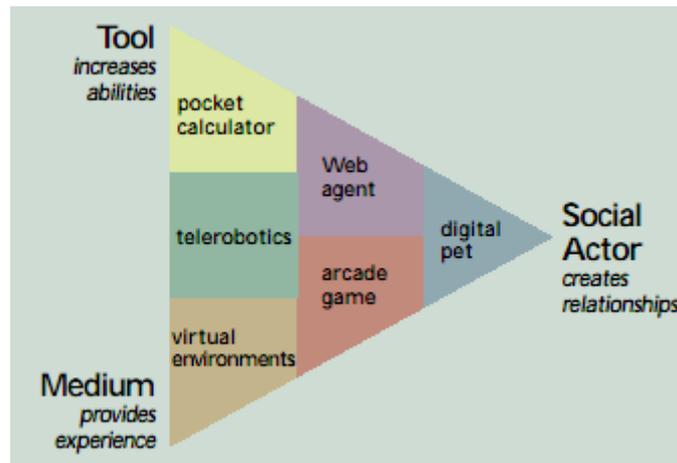


Figure 6: The Functional Triad of Fogg[15]

- **Social Actors** adopt animate characteristics, roles and/or social rules and dynamics. An example is electronic avatars/agents such as Microsoft Word's (in)famous paperclip.

Concluding Finally, of note is the definition of the concepts Macrosuasion and Microsuasion, which are mentioned in his book[12]: Macrosuasion is the overarching behavior that the technology is intended to change, while Microsuasion is the smaller behavior/attitude change step towards the macrosuasion goal. These constructs have a proposed expansion in Atkinson's critical review of Fogg's book published in 2006[5]: Compusuasion, which covers unintended behavioral changes.

The PSD model uses the techniques described in his book extensively: most of the techniques listed by the PSD model are simply an adaptation of Fogg's techniques. Additionally, the concept of type of intent is used at the beginning of the persuasion context description (The Intent - Persuader), to frame the rest of the context.

4.3.2 Principles of Influence

The 6 Principles of influence, also known as "the 6 weapons of influence", were proposed by Cialdini in his book, "Influence: The Psychology of Persuasion" [6]. First published in 1984, the principles of influence are 6 tenets that Cialdini claims have significant impact on whether a person is persuaded to a certain course of action. These principles originate from work he has done undercover with door-to-door sales agencies, car dealers and real-estate companies, analyzing how their sales techniques work. Since publication, these principles have been used and referenced many times. They are:

- **Commitment & Consistency:** If a person commits to a goal, in written or spoken form, (s)he integrates this into his/her self-image. As such, (s)he is more likely to honor this commitment. Even after the original motivation is removed, (s)he is then still likely to honor this commitment, to retain a

consistent self-image. This is in line with the Theory of Cognitive Dissonance published as book by L. Festinger in 1962 [9].

- **Authority:** People are more likely to obey a person in a position of authority. A very well-known example of this is the Milgram experiment [18], where a subject is instructed to administer electrical shocks to another person under the guidance of a researcher, ending in theoretically fatal doses of electricity.
- **Reciprocity:** A well known sales technique, the reciprocity principle states that a user is more likely to accede to a favor of any size if it was preceded by a small gift or favor. According to Cialdini, this is part of human nature to want to repay open debts, even if the two favors are not of comparable size.
- **Liking:** A person is more likely to be persuaded by a person (s)he likes. Cialdini references the Tupperware parties, where products are sold by someone who knows (and likes) the buyer.
- **Scarcity:** (perceived) Scarce availability generates a demand. This demand increases the desirability of a product or service, which can be used to persuade people to a certain course of action (such as buying the product). A simple example for this would be the well known "limited time offer" many companies employ when selling products.
- **Social Proof:** According to Cialdini, it is part of human nature to seek consensus. This is a statement which is echoed in the Theory of Planned Behavior/Reasoned Action Approach, which includes the Subjective Norms/Perceived Norms as a major component in human decision making. As such, when many people perform a certain action, the likelihood of a person also performing this action increases. This principle has been validated by research such as the paper published in 1951 by Asch regarding the effects of peer pressure on judgement [4].

Many of the techniques listed in the PSD model make indirect or direct use of these 6 principles (mainly Social Proof, Liking, Authority and Commitment).

4.3.3 Persuasive Systems Design Model

The final model in this section is the Persuasive Systems Design Model. We use this model as the base for our PISA context analysis since it incorporates elements from many of the previous models, being one of the broadest models available and the most recent publication in its kind. The Persuasive Systems Design Model was proposed by Oinas-Kukkonen & Harjumaa in 2009 [19] and consists of two elements: a context analysis of the persuasive system and a classification of persuasive techniques in use/can be used by this system. We review both elements before applying this to the context of the PISA tool, in the next section.

The Persuasion Context According to Oinas-Kukkonen & Harjumaa, the persuasion context consists of 3 elements: the intent (of the persuader), the event (that triggers the persuasion) and the strategy (by which the subject is persuaded). They are explained below:

- **The Intent:** This pertains to the goal and nature of the persuader. In the intent, the Persuader and the Change Type are distinguished:

- *Persuader*: The person that tries to convey a persuasive message to the subject. This falls into the three categories described by Fogg in his Captology publications: Endogenous, Exogenous and Autogenous.
- *Change Type*: These fall into the categories 'attitude' and 'behavior'. These correspond to the Theory of Reasoned Action's Attitude and behavior. (I.e., attitudes influence behavior and are harder to change). Furthermore, several theories, including the Elaboration Likelihood Model and Information Processing Model, distinguish short-term behavior change and sustained behavior change. As such, we regard change type to fall into the categories 'attitude change', 'sustained behavioral change' and 'short-term behavioral change'. These are also widely considered to range from hard to easy to achieve, respectively.
- **The Event**: The Event is the context in which the persuasion takes place. This is considered by the authors to be an important part of the context analysis. The Event consists of the Use context, User context and Technology context:
 - *Use Context*: The problem domain dependent features of a system. Examples would be the features that should/are present in a system that is developed for reducing smoking, specifically. In the context of PISA, this would be *information security*.
 - *User Context*: Similar to the Use context, the prospective/current users of a system should also be examined. Taking from the Elaboration Likelihood Model, some types of users have a low need for cognition, while others have a high need. This would affect how messages are best presented to the user.
 - *Technology Context*: A system utilizes specific technologies that offer features to and impose restrictions on a system.
- **The Strategy**: Finally, the Strategy examines how a persuasive system interacts with the user. As such, it considers two things, the Message and the Route:
 - *Message*: The message is concerned with the content and the format of the persuasive message. The message can use elements both of McGuire's Information Processing Model (i.e., describing how a message is structured and conveyed to the reader) and Cialdini's Principles of Influence (i.e., using for example the principle of influence to structure the message).
 - *Route*: All persuasive content has to select one of two routes described in the Elaboration Likelihood Model (peripheral, central). Knowing which route to choose greatly affects the persuasive capabilities of a system.

Persuasive Techniques In addition to a way to analyze the persuasion context, the PSD model offers a classification of persuasive techniques that can be utilized by a system using 4 categories: Primary task, Dialogue, Credibility and Social Support. Most of these principles were adapted from Fogg's book, *Persuasive Technologies*[12], augmented and adapted by Oinas-Kukkonen & Harjumaa. No explicit reasoning was given for their selection of techniques beyond the adoption of "many of the design principles (...) have been adopted and modified from Fogg [2003]" [19].

Primary Task Support: Helping the user achieve goals Primary task support techniques are techniques that augment the user's abilities and help them achieve goals. These are often functional parts of the system:

- **Reduction:** Making the task easier for the user to complete. *Example:* listing a few options of an antivirus program so the user does not have to find one him/herself.
- **Tunneling:** Guiding the user through a process. *Example:* a software installer guides the user through an install process.
- **Tailoring:** Adjusting offered information for a certain user group. *Example:* Offering a different interface to a beginner, intermediate and advanced knowledge groups to minimize unwanted information.
- **Personalization:** Adjusting offered information to specific users. *Example:* Offering personalized (and thus probably more relevant) information in a search engine on the first page.
- **Self-monitoring:** Allowing the user to track his/her own progress. *Example:* Offering the user of a fitness trainer the information needed to see how far along he/she is in his long-term training plan.
- **Simulation:** Provide the user with a way to discern the link between cause and effect. *Example:* Before-and-after pictures of people that have lost weight are shown to indicate the effectiveness of a certain training regime.
- **Rehearsal:** Provide the user with a means to rehearse a target behavior. *Example:* A flight simulator for pilots.

Dialogue Support: Techniques used in dialogue with the user These are techniques that are used when interacting with the user, bearing similarities to persuasive techniques used in human interaction:

- **Praise:** Compliment the user when it performs target behaviors. *Example:* A fitness training application compliments the user when he/she has managed to lose weight this week.
- **Rewards:** Reward the user when it performs target behaviors. *Example:* The user earns a virtual trophy when it has followed its fitness program for 2 straight weeks.
- **Reminders:** The system reminds the user to perform a target behavior. *Example:* An antivirus program reminds the user that he/she has not updated in 2 weeks.
- **Suggestion:** The system suggests an appropriate course of action. *Example:* An application promoting healthy eating habits suggests that the user eats a piece of fruit instead of an unhealthy alternative.
- **Similarity:** The system tries to imitate the users in some way. *Example:* An application targeted at young people uses appropriate slang to communicate.
- **Liking:** A system is visually attractive to the user. *Example:* A website targeted at pet owners uses pet-related symbols such as dog's paws for navigation around the site.
- **Social Role:** The system adopts the role of a social actor. *Example:* A fitness application uses a virtual agent that coaches the user, praising and suggesting as appropriate.

Credibility Support: Types of credibility of a system Many factors subtly influence how much stock people put in a system's suggestions and/or opinions. Some of these elements and some notes on the importance of maintaining system credibility are investigated in a 1999 publication by Fogg and Tseng[16]. The techniques below are factors which influence a system's credibility:

- **Trustworthiness:** The system is viewed as truthful and unbiased. *Example:* A website uses a well-known 3rd party to verify the strengths of its products instead of just relying on advertising.
- **Expertise:** The system is viewed as incorporating expertise. *Example:* A system that is known to provide information that is supplied by known experts in the field has more credibility.
- **Surface credibility:** The system should have a competent look-and-feel at first glance. *Example:* a fast, clean and highly polished website without advertising feels more credible at a glance than an old geocities website with popup advertising.
- **Real-world feel:** The user can place the system in a real-world context. *Example:* A company website that has a contact form for questions and/or feedback.
- **Authority:** A system that has/comes from an authority in some way. *Example:* A government website is seen as coming from a source of authority.
- **Third-party endorsements:** A system that is endorsed by a 3rd party. *Example:* An e-shop that displays a certificate guaranteeing that their wares are of a certain quality.
- **Verifiability:** A system can have its information/content verified by other sources. *Example:* Claims on a website are supported by links to relevant sources.

Social Support: Social factors in persuasive ability of a system A persuasive system usually does not operate in a social vacuum. Drawing on the earlier observations from Cialdini where we established that humans are social creatures, it stands to reason that the way the direct environment interacts with the system also has a great effect on the user's interaction with the system. The following factors, then, play a sizeable role in determining the system's persuasiveness:

- **Social Learning:** A system offers a way for users to observe others performing a target behavior. *Example:* A fitness application shares a fitness journal of another user to motivate others to physical exercise.
- **Social Comparison:** A system allows users to compare relative performance. *Example:* Leaderboards in a learn-to-type application shows how well someone is doing compared to other people in his/her skill-bracket.
- **Normative Influence:** A system leverages peer pressure to persuade. *Example:* A smoking cessation application shows pictures of newborn babies with serious health problems due to the mother's smoking habit.
- **Social Facilitation:** A system shows the user how many others are using the system. *Example:* A homework application shows how many children in the user's class are doing homework at the same time.

- **Cooperation:** A system allows multiple users to cooperate to perform a task. *Example:* A homework application giving multiple users parts of an equation to solve in order to unlock a mystery or gain a prize.
- **Competition:** A system leverages a person’s natural drive to compete. *Example:* An online competition such as Quit and Win (stop smoking for a month and win a prize).
- **Recognition:** A system offers public recognition of a user’s efforts to his/her social group. *Example:* names of top contributors in an online wiki are published on a website as “user of the month”.

4.4 Conclusions

When considering what is useful when designing a persuasive system such as the PISA tool, many factors contribute to the overall ability of the system to persuade. Some of this is because of how the user makes decisions, some of this is due to the environment in which the system is deployed, and some of it is in how the system is structured. The models theories below are considered formative works with many experiments designed to validate them- reading these theories grants the user a better understanding of *how* persuasion works and, more importantly, how one can *use* this knowledge to design a system that persuades. Because of the broad theoretical underpinning and recent nature of the PSD Model, the PSD model is applied to a possible context of PISA to structure possible requirements and explore possible ways in which the PISA tool could persuade its users to exhibit safe(r) digital behavior.

5 Applying the PSD model to PISA

First and foremost, the PSD model is a way of looking at a system *in a certain way*. As such, one needs a vision of how the system and its context is structured before one can draw any meaningful conclusion. To gather meaningful information from this context analysis, we do the following things, in the specified order:

- Classify the possible content per element in the context analysis (e.g., The Persuader can be Autogenous, Exogenous or Endogenously motivated). This allows for the comparison of multiple possible contexts of the aspired PISA system.
- Propose a list of possible profiles when creating/using PISA. A profile is defined as a tuple of **provider** and **user**. This allows for the application of the PSD model’s context analysis on several possible scenarios.
- Per usage profile, list the assumptions made to create this scenario. Then, apply the PSD Model’s context analysis using the elements previously classified in step one.

5.1 Classification of PSD context content

To classify and compare different context profiles of a (hypothetical) system, an agreement has to exist as to the possible values the individual parts of the context analysis can have. Since the PSD model does not give explicit values, this section

creates these values for use within the specific profiles established for the PISA system.

The Intent

- **Persuader:** Fogg's 1998 publication[14] lists three types of persuasion (see the Types of Intent section above). This maps to the persuader nicely, yielding the following possible values:
 - *Autogenous:* The persuader is the user of the product;
 - *Exogenous:* The persuader is someone who supplies the product to the user;
 - *Endogenous:* The persuader is the designer of the product.
- **Change Type:** Inspired by the Elaboration Likelihood model as well as several other theories in the field such as the Reasoned Action Approach, Change type is distinguished into 3 categories, which are progressively harder to achieve:
 - *Compliance:* Can also be seen as short term behavioral change. Covers the instances in which single acts of compliance are achieved;
 - *Structural Behavior Change:* A permanent change in behavior without necessarily influencing the beliefs and values of the user;
 - *Attitude Change:* A change in values and/or beliefs of a user (i.e., "security is important").

The Event

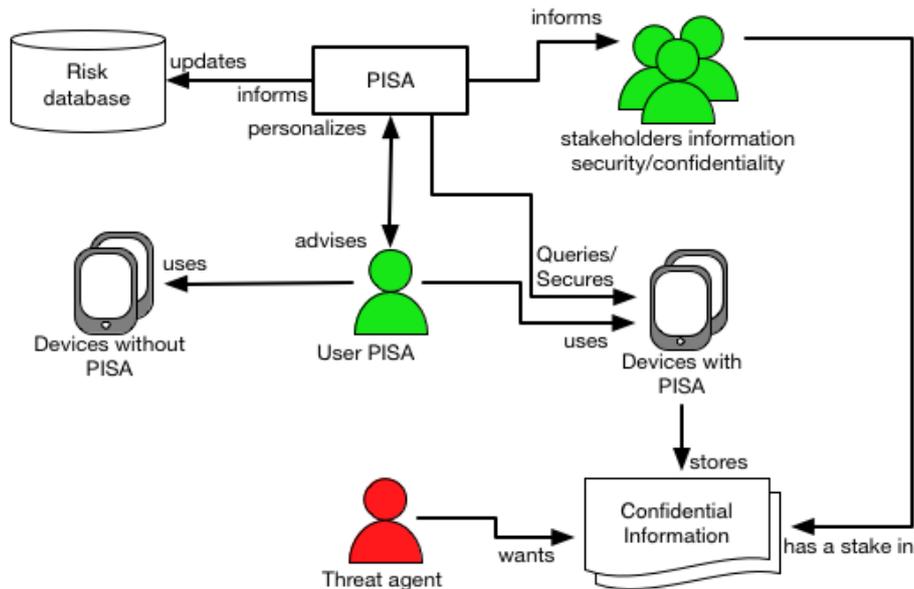
- **Use Context:** This part of the context analysis is most prone to special characteristics and has no clear theoretical basis. For the purposes of PISA, the following categories are distinguished, with progressively weaker security properties:
 - *Work:* A system that is running on a corporate network with all restrictions that apply generally to such an environment (corporate firewalls, rigorous spamfilters, browsing restrictions etc.);
 - *Home:* A system that performs in a private environment, with varying degrees of security (typically a firewall and virus scanner on the device, but no browsing restrictions etc);
 - *Public:* A system that is accessed in a public location such as an internet cafe or a public WiFi access point (No trusted firewall, possible eavesdroppers etc.).
- **User Context:** Taken from the Elaboration Likelihood Model, the following categories are distinguished:
 - *Low/High Motivation Level:* The amount of motivation that a user has to interact with the system and heed its instructions;
 - *Low/High Skill Level:* The amount of skill and knowledge that a user has w.r.t. security, computers and other factors relevant to PISA.
- **Technology Context:** Taken from the author's speculations on likely technological factors in the creation of the PISA system, the following categories are distinguished:

- *Digital Agent, Work Device*: Interaction occurs via an agent application installed on a work device;
- *Digital Agent, Private Device*: Interaction occurs via an agent application installed on a device used at home and/or public locations;
- *Website*: Interaction occurs via a website available to the user;
- *Mail*: Interaction occurs via mail sent to the user.

The Strategy

- **Message**: Taken from the PSD model techniques for persuasion, with an emphasis on Primary Task Support and Dialogue techniques. Refer to the PSD section of the document for more details.
- **The Route**: Taken from Dual process theory, more specifically the Elaboration Likelihood Model:
 - *Central*: Users are informed in order to persuade them;
 - *Peripheral*: Users are guided using cues and meta-information in order to persuade them.

5.2 Company/Employee profile



The assumed context is depicted above. A list of the most pertinent assumptions can be found below:

- The PISA tool is used in an organizational context. That is to say, it is distributed by an employer to employees of the company in order to secure company information.
- The user has to install PISA on every device that has company information stored on it. It is, however, infeasible to say that all devices that the user

interacts with are secured by PISA. As such, the user uses 2 sets of devices: one with the PISA client, the other without. Devices that are not secured by PISA should not contain any confidential information.

- The PISA client communicates with the supervisor of the PISA user to inform the user's superior as to the user's current security status. This allows the supervisor to check whether all confidential information of a company is secured.
- An external risk database exists which contains information needed for the PISA to identify and address threats to the devices it secures. The PISA client helps the risk database evolve by informing it of events on the user's devices.

5.2.1 PSD Model applied to PISA

When the assumptions above are applied to the system, the following persuasion context exists, according to the PSD Model:

The Intent

- **Persuader:** In this case, the main persuader is **exogenous**: the company which distributes the PISA tool. Small amounts of Autogenous motivation may exist if the user feels the PISA tool helps him/her personally in establishing safer digital behaviors. Endogenous motivation (coming from the developer: the researchers) is mainly an academic interest and not of real influence when considering the commercial product's stakeholders.
- **Attitude Change Type:** Though attitude and structural behavior are good goals when considering the endogenous and autogenous factors at play, the exogenous persuader is most interested in **compliance**.

The Event

- **Use Context:** The PISA tool in this context profile is a tool that is used at work. Though possibly installed on devices that are carried to a home environment, when the user interacts with the PISA system outside of a work environment, (s)he changes to the next profile, Worker at Home. As such, the main use context in this case is **Work**.
- **User Context:** When considering the PISA tool to be a system that is distributed by the company to protect confidential information, the user probably has **low motivation** to adopt the technology, with both **low and high skill levels** available.
- **Technology Context** In this context, we consider that work devices are the main devices to be secured. As such, **Digital Agent, work device** seems logical, with **Mail** if such a technology is used in creation of the system.

The Strategy

- **The Message** Due to the low motivation of subjects and the tool's intrusion in existing processes, the PISA tool's messages should be short and to the point, aimed at quick, non-onerous tasks, rather than educating the user.

Communication should be kept to a minimum and oriented around obligation to obey authority rather than relying on a user's intrinsic motivation. As such, **Reduction** and **Reminders** seem important, and due to the wide range of skill levels, **Tailoring** should play a major part as well.

- **The Route** As the change type is mainly oriented around short-term behavior change and the user context specifies a low user motivation, messages should prevalently be structured around the **peripheral** route.

5.3 Companee/Worker from home profile

This profile is essentially the same as the one above, with one major difference: The majority of interaction with the PISA tool is in a home environment, with associated risks. Below the relevant conclusions:

The Intent

- **Persuader**: Unchanged from previous: **Exogenous** motivation.
- **Change Type**: Unchanged from previous: **Compliance** is desired.

The Event

- **Use Context**: Due to use at home, other risks come into play. Both **Work** (when the user takes its devices to work) and **Home** environments have to be considered.
- **User Context**: Unchanged from previous: **Low Motivation** and both **low and high skill level**.
- **Technology Context** both **Digital Agent, private device** and **Digital Agent, public device** have to be considered since sensitive information may be stored on private computers.

The Strategy

- **Message**: Largely unchanged from previous, with possibly more compulsory actions (i.e., forbidding an installation) to take into account other, non-employee users accessing the computer. **Reduction, Reminders and Tailoring** with possibly **Tunneling** added in.
- **Route** Unchanged from previous: **Peripheral** route.

5.4 Worker from home/Worker from home profile

Though the context is the same as the previous two profiles, in this case the device is installed by the Worker from Home, rather than being mandated by the company to do so. This has a large impact on several elements:

The Intent

- **Persuader**: **Autogenous motivation**, since the user elects to install the tool voluntarily.

- **Change Type:** Since the user is acting out of free will, compliance is quite certainly not a goal. Likewise, voluntary installation of the tool suggests attitude changes are not likely a goal of the user. As such, **Structural behavior change** seems most likely.

The Event

- **Use Context:** both **home** and **work** are likely environments.
- **User Context:** Due to the need for a behavior change and voluntary adoption of the technology, the user is probably **highly motivated** with a **low skill level**.
- **Technology Context:** Like the previous profile, both **Digital Agent, private device** and **Digital Agent, work device** are probable profiles. Though mail reminders are possible, they are less likely when not directly supported by company infrastructure.

The Strategy

- **Message:** Due to the autogenous and highly motivated nature of the user, **self-monitoring, simulation** and **rehearsal** are important techniques.
- **Route:** Because of the highly motivated nature of the user, the Elaboration Likelihood Model suggests the **central** route as the most effective one, both to achieve structural behavior change and because of the motivation level of the user.

5.5 Parent/Child profile

This profile simulates the use of the PISA tool to secure a computer that is used by the children of the user. As such, the primary user is regarded as the child, while the supplier is the parent. This profile can, of course, overlap with any of the Worker at Home profiles.

The Intent

- **Persuader:** **Exogenous** motivation, since the parent installs it so the child can use it.
- **Change Type:** This depends on the goal of the parent when installing the tool. It could be **attitude change** or **structural behavior change** if the intent is to educate the child, or simple **compliance** if the primary intent is to secure the device; quite possibly it is a mix of all three.

The Event

- **Use Context home.** Whereas in previous profiles the main threat was confidentiality, here the primary concern is probably the integrity of the device.
- **User Context: Low Skill level** and **Low Motivation.**
- **Technology Context: Digital Agent, private device.**

The Strategy

- **Message:** Most messages should come in the form of games. As such, **Praise**, **Rewards** and **Liking** should play an important role in the system.
- **Route:** The attitude change should be primarily affected by the **peripheral route**. If the PISA tool is structured as an educational game, it could attempt the **central** route, but should be careful to engage the child lest the message be lost entirely.

5.6 IT service provider/IT service consumer profile

This profile is structured around the idea of PISA being a feature provided as assurance mechanism in an existing IT service. As such, it is completely integrated in the IT service itself (f.ex., a security module in facebook).

The Intent

- **Persuader:** *Exogenous*, since it is supplied by the service provider.
- **Change Type:** depends on the reason it is implemented: **attitude change** if it is marketed as an awareness campaign for security, **structural behavior change** if it is presented as a tool that helps the user improve his/her security habits, and **compliance** if it is a requirement to use (parts of) the IT service. In the last case, the system is probably a risk-management tool for the IT service provider. We assume the second case: It is supposed to help users develop more secure digital habits.

The Event

- **Use Context:** Since the service is quite certainly a web based service, contexts can vary: **Home**, **Work** and **Public** are possible.
- **User Context:** Both **high and low skill levels**, with **high motivation level**, considering the chosen change type.
- **Technology Context:** **website**, considering the chosen profile.

The Strategy

- **Message:** Since it is part of an IT service, **tunneling** and **Suggestion** seem likely candidates: Tunneling to help set up options in the IT service and suggestion to offer a course of action while using the service.
- **Route:** **central**, considering the high motivation level.

5.7 IT service provider/IT service consumer profile (enabled scenario)

A variant of the last profile, in this case the IT service uses devices that are not within control of its service provider (f.ex., an internet banking service that offers a smartphone application to access its service).

The Intent

- **Persuader:** Unchanged from previous profile: **Exogenous**, supplied by the IT service provider
- **Change Type:** Unchanged from previous profile: While all 3 are possible, **structural behavior change** is assumed as the aspired change.

The Event

- **Use Context:** Since the profile assumes devices outside the control of the IT service provider, **home** seems the most plausible context.
- **User Context:** Unchanged from previous profile: **high and low skill levels** and **high motivation level**.
- **Technology Context:** A combination of **website** and **Digital agent, private device**.

The Strategy

- **Message:** Unchanged from previous profile: **tunnelling** and **suggestion**.
- **Route:** Unchanged from previous profile: **central** route.

6 Conclusions

This report has covered a large amount of literature pertaining persuasive technology, covering Psychology as well as Computer Science. This literature review was performed to create an understanding of human reasoning and interaction with the computer, as well as providing a better understanding into the process of persuasion. An insightful model of human decision making is was found to be the **Reasoned Action Approach**, while the most comprehensive model of persuasive system design was found to be Oinas-Kukkonen and Harjumaa's **PSD model**. The latter has yielded insights regarding the creation and hypothetical deployment of the PISA tool, which is proving useful in the requirements phase of the subsequent prototype development.

6.1 Limitations

Three limitations exist in this literature review:

- **Database limitation:** this literature review was of a limited nature, since the complete set of databases (i.e., all of the initially listed scientific databases excepting scopus) was considered too large for the current timeframe. Nonetheless, many dominant models and theories were covered, and as such, the results can be considered relevant to the development of PISA.
- **Case Study exclusion:** Though many models were covered by this literature review, due to constraints on the scope of this research, all single-case studies were excluded from the results. Though they do not offer new models or theories on their own, they are a valuable tool in the validation of the models that were covered in this report. As such, validation of the covered models is considered to be out of the scope of this research.

- **Category limitation:** In Step 4 of the method used to gather sources for this literature review, papers were classified in 4 categories, of which two categories (security and sidetracks) were disregarded in the current literature review. As such, some documents that may have been useful for PISA’s development have been excluded at this time.

6.2 Research questions

At the beginning of this report, two questions were asked. The first one, *“what models and theories related to persuasive technology exist”*, has largely been answered in the Overview of Literature section. Limitations leading to the possible exclusion of some models and/or theories have been explained in the previous section. The answer to the second question, *“Which model is most suited to assist in the design of the PISA tool as a persuasive system”*, is Oinas-Kukkonen and Harjumaa’s PSD Model, being a distillation of previous knowledge, combined with a marked shift to practical application.

6.3 Application to PISA

The results of this literature review have led to the creation of the analysis of several possible contexts in which the PISA tool could be deployed. Furthermore, it has given insight into the persuasive process and ways in which persuasion can be employed to further the effectiveness of the PISA tool. As such, the results of this work contribute by offering knowledge to the designers of this tool.

6.4 Future work

Several avenues of further research exist:

- The literature review can be extended by including the other 6 scientific databases. Results from these databases may include previously disregarded models and theories, offering new insights.
- Models and theories covered in this review could be further examined for validity by finding and including single case studies designed to test these models/theories.
- The last two categories defined in step 4 of the method could be examined for further lessons and insights for the development of the PISA tool.
- The effectiveness of the techniques listed in Fogg, Oinas-Kukkonen and Harjumaa’s research could be further researched by identifying real-world software which incorporates these techniques to persuade, examining the effectiveness of these specific products.

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