# An Effect Evaluation of a Nutrition-Related Serious Game: King of FoodLand

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## Abstract

**Objective** A large part of the Dutch population does not comply with Dutch nutrition guidelines and also lacks nutrition knowledge. Serious games are a promising communication strategy for improving nutrition knowledge. Therefore, an effect evaluation was conducted on a nutrition-related serious game ("King of FoodLand") among Dutch speaking adults. This study assessed whether such a game is an effective tool to improve nutrition knowledge and whether motivational factors contribute to potential knowledge effects.

**Methods** In a one-group pre-test/post-test design, 20 Dutch speaking adults completed a pre-test, assessing their prior nutrition knowledge. In an intervention of two weeks participants could play the first 15 levels of the game as often as they liked, whereby their actual game play was tracked. The levels addressed the topics energy, macronutrients and vitamins. The post-test assessed their potential knowledge improvement, their situational interest and their motivational factors such as self-determined motivation and game flow.

**Results** Significant nutrition knowledge gains were detected. In particular, knowledge about energy significantly increased. Self-determined motivation significantly influenced game flow, and self-determined motivation was significantly associated with situational interest. However, self-determined motivation did not explain the effects on nutrition knowledge and were also not mediated by game flow or actual game play in this current study.

**Conclusions** Results showed improvements on nutrition knowledge. Further research should explore whether the effectiveness is also applicable to a larger sample size, whether it is applicable when a control group is included and which particular motivational factors contribute to knowledge improvement.



Keywords: Serious Games, Nutrition Knowledge, Nutrition Education, Motivation, Learning, Effectiveness Evaluation

## Preface

As a child I grew up in a family that motivated me to play without any technical devices, but rather encouraged me to draw from my imaginations. Yet, since my childhood, technical devices developed and became increasingly popular that we can barely image a life without these devices. Entertaining purposes and distraction from daily occurrences form success factors for the gaming industry. Smart devices and related apps make it possible to play games in-between daily obligations. Since I did not grow up with digital games, I always had a rather critical attitude towards digital games, as I considered them being time-wasting and holding someone back from living his/her real life.

A presentation by Jane McGonigal on TEDTalks convinced me to rethink the purposes of digital (video) games, as she suggests that games could exist as a parallel education, as long as the gaming industry implements relevant topics. Therefore, so-called serious games became the topic of interest for my master thesis. Both, my doubts and new insights about serious games, as well as my specialization in health promotion shaped my interest to research the actual effects of serious games with regard to health benefits.

In the following, you are about to read the results of my study that I conducted for the Master of Science in Applied Communication Science at Wageningen University (Wageningen, the Netherlands). I experienced a lot of setbacks during the research process as a lot of things turned out to be different in reality than I anticipated. Yet, they strengthened my research skills and I figured out that I really enjoy conducting quantitative research.

My first supervisor, Emely de Vet, supported me with regard to the content as she gave me regular feedback via e-mail and in person. She did not only support me content-wise, but also encouraged me when my research did not turn out as planned. I really enjoyed working with Emely as she continuously guided me with her expertise and her good humor. My second supervisor Anouk Geelen has been recommended by Emely de Vet for supervision. With her critical thoughts on the topic as well as on my experiment I have been able to progress my work. Louise Witteman - the developer of the game ‘King of FoodLand’ (that is subject to this thesis) - has always been willing to help me out, thought along with my ideas and encouraged me to think out of the box. Barry Hoffman supported me in collecting and structuring the data of the game and taught me how to analyze the data. I really want to thank Louise and Barry for the intensive e-mail and skype contact. Furthermore, I want to thank Annie Kurowski for her remarks language-wise.

My special thanks also go to Jacob, who not only loaned me his iPad for some months to be able to play the game, but also encouraged me in my research choices during writing my proposal. Also, I want to thank Johanna, Clara and Anna for their critical view on my project, our lively discussions about my thesis topic and their incredible remarks for improving the end product. Besides thanking my

friends and family for their support, I want to thank Berl for recruiting Dutch participants for my research and his motivating speeches.

Finally, I hope that my study's results will contribute to an improvement of the game 'King of FoodLand' and to a better understanding of the effects of serious games.

Ayla Schwarz

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## Figures and Tables



**Abbreviations**

| | |
|---|---|
| App | Application |
| EEVA | Eigenvalue |
| EU | European Union |
| EuroFIR | European Food Information Resource |
| NLAI | Nutrition Literacy Assessment Instrument |
| PEV | Percentage of Explained Variance |
| SES | Socio-economic status |
| WHO | World Health Organization |

# Introduction

According to the Health Council of the Netherlands, it is recommended to daily consume 200 grams of vegetables and fruit, 90 grams of whole-grain products, 15 grams of unsalted nuts, three cups of tea and several portions of dairy products. Furthermore, it is recommended to weekly consume (fatty) fish and pulses (Gezondheidsraad, 2015). A Dutch national consumption survey of 2007-2010, however, has shown that only 4-26% of Dutch people adhere to these recommendations for fruit intake and only 3-14% for vegetables intake. Moreover, 88-92% have a higher intake of saturated fat than recommended (van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocké, 2010). This consumption pattern is associated with an increased risk of developing non-communicable chronic diseases. In the Netherlands, 5.3 million people suffer from non-communicable chronic diseases, which is comparable to the mean prevalence of the European Union [EU] (Gijsen, van Oostrom, Schellevis, & Hoeymans, 2013). According to the World Health Organization [WHO], cardiovascular diseases count for 29% of deaths, cancer counts for 33% of deaths and diabetes for 2% of deaths in the Netherlands (World Health Organization, 2014b). One risk factor for developing non-communicable chronic diseases is not adhering to dietary guidelines (Springvloet, Lechner, de Vries, Candel, & Oenema, 2015). The majority of premature non-communicable chronic diseases can be prevented by lifestyle changes and health care improvements (World Health Organization, 2014a). One lifestyle change is compliance with dietary guidelines and therefore, must be promoted among individuals (Springvloet et al., 2015).

A systematic review has shown that nutrition knowledge is associated significantly positive, albeit weak with a healthy dietary intake. Higher nutrition knowledge is in particular associated with higher intake of vegetables and fruit and a lower intake of fat. Also, a greater intake of fish, cereals, fiber, calcium or food groups, which are recommended by dietary guidelines, is associated with greater nutrition knowledge. Furthermore, lower intake of sweetened drinks is associated with higher nutrition knowledge (Spronk, Kullen, Burdon, & O'Connor, 2014). Another systematic review studied the association between food literacy and adolescents' dietary intake. The study reveals that adolescents' food literacy may be associated with shaping adolescents' dietary practices. Food literacy means the knowledge, skills and behaviors people have and perform to meet their nutritional needs and food intake. Thereby, people are for example enabled to meet nutrition guidelines (Vaitkeviciute, Ball, & Harris, 2014). Furthermore, high levels of nutrition knowledge are influenced by a higher socio-economic status [SES] and a higher education level. People with a higher SES and a higher education are more likely to comply with dietary guidelines (McKinnon, Giskes, & Turrell, 2014). Hence, it seems important to further promote nutrition knowledge. Thereby, inequalities of nutrition knowledge as well as differences in food literacy can be tackled and nutrition knowledge can be further promoted.

The Dutch market research institute TNS NIPO conducted a survey among 1000 Dutch people in 2013, which shows that 70% perceived a lack of nutrition knowledge or misconceptions about e.g.

fatty acids, daily recommended amount of calories and body mass index (Fivit bedrijfsdiëtisten, n.d.). A study from 2012, conducted by the Dutch Nutrition Center (Voedingscentrum) reveals that one out of eight Dutch people reported that he/she does not have significant nutrition knowledge. In comparison, 6% indicated significant nutrition knowledge (Temminghoff & Van Oirschot, 2012). Nutrition knowledge was measured by means of a facts and fables check, meaning that respondents (N=1003) were asked to indicate whether statements were true or false. Results show concrete examples of misconceptions about nutrition among Dutch people. For example, even though 62% know that one glass of fruit juice contains the same amount of sugar and energy as a glass of soda, people, who are aged older than 50 years old are less aware about that fact. However, they do know that 'eating six times a day helps losing weight in comparison to 3 times a day' is a fable (Temminghoff & Van Oirschot, 2012). Besides the fact that only a small percentage of Dutch people complies with dietary guidelines, large parts of the Dutch population has a lack of nutrition knowledge. Therefore, improving nutrition knowledge must be promoted among the Dutch population.

In order to improve nutrition knowledge among a population, nutritional education programs are increasingly implemented (Spronk et al., 2014). Yet, most nutrition education interventions show weak results (Peng, 2009). A new strategy to educate people is serious games. After the foundation of the Serious Games Initiative in Washington D.C. in 2002, serious games became a well-known term and concept. Even though various definitions exist in literature, authors agree on the global definition that serious games are "*(digital) games for purposes other than mere entertainment*" (Susi, Johannesson, & Backlund, 2007, p.1). Serious games are designed for educational purpose (serious) with a game play structure (game) (Djaouti, Alvarez, & Jessel, 2011). Zyda (2005, p.26 in: Djaouti et al., 2011, p.4) defines serious games as "*a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives"*. Thus, learning with the outcome of new knowledge or skills is central to serious games (Susi et al., 2007). In addition, motivation is important to ensure actual game play and eventually behavioral change (Baranowski, Buday, Thompson, & Baranowski, 2008). Thus, 'serious' can be understood as the learning part, whereas 'game' is linked to motivation and fun; yet, both intertwine.

One growing application field of serious games is healthcare (Djaouti et al., 2011). A meta-analysis shows that serious games improve healthy lifestyles, even though the relationship is statistically weak. Yet, serious games show promising results for knowledge improvements, even in the long-term (DeSmet et al., 2014). The relationship between knowledge and behavior, affected by serious games is statistically weak. However, tailoring games to socio-demographic information and behavioral change needs such as knowledge or motivation contribute to the games' effects (DeSmet et al., 2014). Nutrition knowledge is according to McKinnon et al. (2014), a mediator of socio-economic inequalities in food choices and enables a wide range to promote health through education.

Furthermore, it is shown that a sample of Dutch people (N=1003) search particularly for nutrition information on health websites (35%) rather than visiting a doctor or dietitian (5%) (Temminghoff & Van Oirschot, 2012). Individuals with a lower SES tend to be users of technology rather than print media (McKinnon et al., 2014). This offers an opportunity to make use of serious games to improve individual's nutrition knowledge.

Since the field of serious games is new and therefore rather unexplored, scientific research on serious games needs to advance. A study of Baranowski et al. (2008) studied the effects of serious video games on health behavior change and points out that a sufficient amount of research about serious games is lacking and "*requires models of pathways of effects, and testing theory-based propositions*" (Baranowski et al., 2008, p.81). Also, the effectiveness of serious games in health interventions still needs to advance (Peng, 2009). For societal means an effect evaluation of a serious game is of high value, as factors which motivate people to gain nutrition knowledge can be identified. This can help in the design of effective interventions, which could potentially assist individuals to acquire nutrition knowledge and eventually adapt to healthy food sources and therefore live healthier lives.

A large part of the Dutch population lacks sufficient nutrition knowledge. However, serious games indicate a promising strategy to educate people globally. As scientific research is limited and society can profit from well-designed serious games, there is a need to analyze the effectiveness of serious games in nutrition education. King of FoodLand, developed by Robin Health Games, is a smartphone web application [app] with its primary purpose to increase nutrition knowledge among adults in order to encourage healthy behavior. Overall, King of FoodLand is a serious game, which seems to be a promising strategy to increase nutrition knowledge among a large target group. Serious games combine learning with motivation, which ensures actual game play and learning (All, Nuñez Castellar, & Van Looy, 2014). Only when people continue playing the game and thus go through an engaging game experience, they can receive new information and thereby potentially increase their knowledge. Motivation is required to ensure knowledge gain. This study will test whether nutrition knowledge can be improved by means of a serious game and whether motivational factors contribute to potential effects. By means of the nutrition-related serious game King of FoodLand, an effect evaluation will be conducted with the following research questions.

## Research Questions

*Main Research Question*

Is the serious game King of FoodLand effective in improving nutrition knowledge among Dutch speaking adults, and are motivational factors, related to the game influencing the effectiveness?

*Sub Research Questions*

a. Does King of FoodLand lead to an improvement of nutrition knowledge among Dutch speaking adults?

b. Does the game experience of Dutch speaking adults determine the effectiveness of King of FoodLand?

c. Does King of FoodLand motivate Dutch speaking adults to play the game and to potentially learn about nutrition?

It will be tested whether playing the serious game King of FoodLand is effective on gaining nutrition knowledge. Nutrition knowledge in this study refers to the particular knowledge, which is taught in the game. In order to determine whether motivational factors contribute to the effectiveness, it will be tested whether game experience determines the effectiveness of King of FoodLand. Also, it will be tested whether the game is motivating to play and whether it influences potential effects on nutrition knowledge. Thus, whether motivation has an effect on knowledge, whether it is mediated by game experience and whether it is related to situation interest in the topic of nutrition (Figure 1). This will contribute to research advances on serious games in health promotion, particularly in nutrition education.

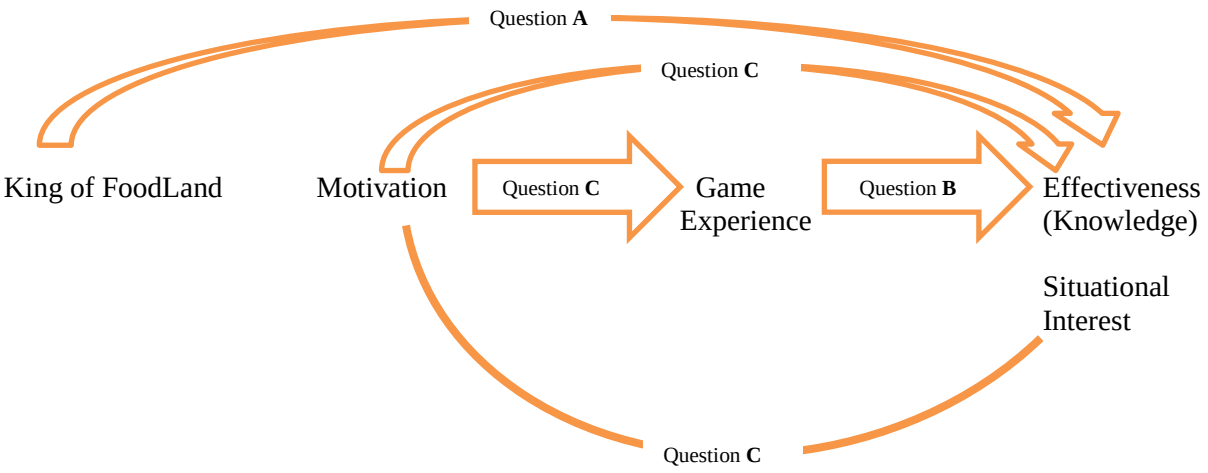



**Figure 1. Schematic Overview of the Research Questions.**

## Research Objective

This thesis aims to examine the effectiveness of one nutrition-related serious game on improvements of nutrition knowledge: King of FoodLand. Thereby, it can be assessed whether a serious game on nutrition is an effective tool to teach and gain nutrition knowledge, the primary focus and purpose of the game. Furthermore, it shows whether a serious game is a motivating strategy to promote nutrition education.

## Thesis Outline

After introducing the scientific approach of serious games, the second chapter will present the theoretical framework and will conclude with the hypotheses of this study. The third chapter will present the methodology and chapter four will present the results of this study. The final chapter will draw a conclusion to the main research question and conclude with the strengths and limitations of this study to determine which topics should be the subject of further research.

# Theoretical Framework

## Effectiveness Evaluation

According to All, Nuñez Castellar and Van Looy (2015), digital game-based learning needed a systematic evaluation framework in order to test the effectiveness of games. Effectiveness is defined "*as the successful attainment of its intended goals in a real-world context*" (All et al., 2015, p.30). The framework states that three components are important in order to test effectiveness: 1) learning outcomes, 2) motivational outcomes and 3) efficiency outcomes.

The learning outcomes are threefold. First, *situational interest* includes whether the game results in an increased interest in the topic. Applied to the current study, the game King of FoodLand aims to increase interest in nutrition. Second, *performance* means whether the player reaches the learning goal(s) of the game developer. In this case it means whether knowledge, awareness or even behavioral change occurs. Third, *transfer* indicates whether the player succeeds in applying learned content to real-world settings; thus, whether the player manages to apply new knowledge to his or her nutrition behavior, or eating patterns.

The motivational outcomes are twofold. First, *enjoyment* means a positive game experience. This keeps players motivated to continue playing. Second, *motivation towards digital game-based learning* indicates the instructional method used in comparison to other methods. In this case it means whether the player is motivated to learn with the game-based method King of FoodLand.

Lastly, the efficiency outcomes include *time management* and *cost-effectiveness*. Whereas the former means the required time frame to educate people, the latter expands on the total reach of learners. In the context of King of FoodLand it means how long it takes to teach individuals nutrition knowledge and how many individuals can be reached by means of the game.

The definition of digital game-based learning overlaps with serious games. Whereas digital game-based learning has its application field primarily in education and learning, serious games can have a wider range of application fields, such as military, government and healthcare (Breuer & Bente, 2010). King of FoodLand is a serious game, as it has its application field in health. However, it primarily focuses on knowledge gain, and thus learning. Therefore, the systematic evaluation framework of digital game-based learning effectiveness is applicable to the serious game King of FoodLand. The current study will systematically test the effectiveness of a nutrition-related serious game in terms of its learning and motivational outcomes, since motivation is required to stimulate effective learning. The following two parts of this chapter will outline the underlying theoretical underpinning of learning and motivational outcome and link the concepts to the evaluation framework of All et al. (2015). Thereby, an effect evaluation can be systematically conducted, which is supported by complementing theoretical underpinning. The learning part explains the learning experiences model as well as the

concept of situational learning in detail. The motivational part outlines the self-determination theory and the game flow theory in detail. The chapter will conclude with an adapted evaluation framework for testing systematically the effectiveness of serious games and present the hypotheses of this study.

## Learning

In order to teach new knowledge or skills, serious games can engage people in active learning. Active learning can be stimulated by providing a goal-oriented, (inter)active and contextualized game, which is interesting, challenging and provides feedback (Shute & Ke, 2012). Thereby, the serious game shapes for example a learning environment to learn about nutrition. Games support a cognitive process, in the sense that they are not content-specific, but players develop competencies, for example knowledge over time, as from one level to another. Thus, the player is continuously in a learning interaction with the game, whereby learning is situated in the context (Shute & Ke, 2012).

### Learning Experiences Model

In experiential gaming, learning is referred to as the construction of cognitive structures, by engaging actively in the game world practices. Learning experiences can be classified in two phases, the cognitive learning phase and the affective learning phase. The cognitive learning phase includes: 1) *knowledge acquisition*, thus making sense of the content. Furthermore, the 2) *practicing and processing* is the deep understanding of the content and 3) the *application* of knowledge (Abdul Jabbar & Felicia, 2015). These relate to the learning outcome *performance* of the evaluation framework by All et al. (2015). Applied to the current study, it is assessed whether playing King of FoodLand leads to an improvement of cognitive learning, meaning whether people acquire nutrition knowledge. The second phase includes the 1) *knowledge anticipation*, which means that learners have interest in learning (Abdul Jabbar & Felicia, 2015). This is in line with the *situational interest* of All et al. (2015). 2) *Reflection* means that learners are able to apply the learned content and use it for their own learning (Abdul Jabbar & Felicia, 2015). This is in line with *transfer* of All et al.'s framework (2015). In this study King of FoodLand could for example activate interest in nutrition. Eventually it is expected that people apply their acquired nutrition knowledge to their daily practices of nutrition behavior. The learning experience model states that emotions and thoughts are both decisive for the learning process and engagement (Abdul Jabbar & Felicia, 2015).

### Situational Interest

In detail, s*ituational interest* enhances learning, as it increases an individual's intrinsic motivation to learn. In particular, it is activated by environmental factors, for example an engaging text and arises spontaneously (Schraw, Flowerday, & Lehman, 2001). Applied to the current study, King of FoodLand could activate individual's interest in nutrition. In comparison to personal interest, situational interest is temporary and occurs immediately, between an individual and an activity and is therefore context-dependent. Personal interest rather develops slowly over time and is the preference of a particular activity, thus topic-specific and relies on previous experiences (Chen, Darst, &

Pangrazi, 1999). Hence, it can be expected that the game triggers situational interest. Furthermore, autonomy and choice increase intrinsic motivation and situational learning. In addition, text organization variables, as coherence, relevance and vividness, as well as prior knowledge and active learning are revealed to influence situational interest (Schraw et al., 2001).

## Motivation

According to All, Nuñez Castellar and Van Looy (2014), motivation during game play is often measured by concepts of enjoyment, fun and immersion. Also, it is stated that motivation is highly important to feel engaged and to continue playing, which encourages learning (All et al., 2014).

### Game Flow Theory

In gaming literature it is often referred to (game) flow, which is the psychological state of enjoyment and learning. Enjoyment describes game involvement, whereas (game) flow describes the feeling of enjoyment when a person is engaged in an intrinsically rewarding activity and manages a balance between skill and challenge, feels of being in control and experiences time distortion. The individual becomes one with the activity. It is revealed that a (game) flow state enhances learning (Brockmyer et al., 2009). Fu, Su, and Yu (2009) have adapted the GameFlow model of Sweetser and Wyeth in order to make it more explicit to learning. It proposes that the (game) flow experience, which is originally developed by Csikszentmihalyi is influenced by factors as "*immersion, clarity of goal, autonomy, feedback, concentration, challenge, and skill, as well as the additional factor of player interaction*" (Fu et al., 2009, p.102). The EGameFlow scale developed by Fu et al. (2009) measures eight factors. This reflects the concepts of game experience, which is called *enjoyment* in the evaluation framework by All et al. (2015). Applied to the current study, it can be expected that King of FoodLand applies various factors to involve the player in a game flow in order to enhance learning effects. The factors are described by Fu et al. (2009) as follows:

1. Concentration: Encouraging activities in the game to stimulate attention while minimizing stress from learning overload.
2. Clear Goal: Clear task description in the beginning of the game.
3. Feedback: Allows the assessment of current knowledge stage and required knowledge stage in order to be able to complete the game task.
4. Challenge: Challenges that fit the player's skill level and increase when player's skill level increases.
5. Autonomy: Ability to assert total control over his/her choices in the game.
6. Immersion: Leads the player into a state of involvement, which means that the person is graded and engaged in an experience in one moment in time. The person is neither aware of the real world, nor the time. Yet, the person is emotionally involved in the task environment (Jennett et al., 2008).
7. Social Interaction: Provides tasks that allow the player to interact socially.

8. Knowledge Improvement: Increases the player's level of skills and knowledge.

## Self-Determination Theory

A theory describing the motivational process of a person is the self-determination theory. A summarizing article by the theory developers Deci and Ryan (2008) on the self-determination theory will lead through the following explanation. Even though the article of Cooke, Fielding and Louis (2015) focuses on pro-environmental behavior, it will complement the article by Deci and Ryan (2008), since it summarizes the self-determination theory in detail. The self-determination theory differentiates various types of motivation, which human beings can have towards particular behaviors or activities (Deci & Ryan, 2008). The continuum of motivation types ranges from amotivation via externally related motivation to internally regulated motivation (Cooke et al., 2015). Autonomous motivation, including externally and internally regulated motivation is related to the self, whereas controlled motivation, meaning external or introjected regulation is related to external pressure. Amotivation is the absence of intention and motivation (Deci & Ryan, 2008). Motivation internalization develops since humans want to align their rationales for behavior to their self-identity. External sources or situations can either support or hinder the internalization of motivation. This depends on the human's need for autonomy (volition and choice), relatedness (connectedness to others) and competence (effective to achieve outcomes) (Cooke et al., 2015). Thus, the causality orientations of people, meaning their orientation towards new information when regulating their behavior is dependent on the extent of being self-determined. Self-determination can include a variation of the three basic needs: whereas the autonomous orientation represents the satisfaction of all three needs, the impersonal orientation is the hindrance of all three needs. Strong controlled orientation is the satisfaction of the need of competence and relatedness, but the hindrance of the need of autonomy. In terms of life goals, studies show that intrinsic goals are associated with greater behavioral change (Deci & Ryan, 2008). This draws back on the EGameFlow scale by Fu et al. (2009). Applied to the current study, it means whether an individual is intrinsically motivated to play the game King of FoodLand, whereby the individual's orientation towards new information is dependent on the extent of being self-determined.

In addition to the global conceptualization of the self-determination theory, it is mentioned that awareness is important in developing an autonomous functioning and thus behavioral change (Deci & Ryan, 2008). Also, it has been determined that intrinsically motivated players have "*higher levels of enjoyment, interest, performance, higher quality of learning and a heightened self-esteem*" (All et al., 2014, p.4). Intrinsically motivated players are considered to be more likely to be stimulated for learning (All et al., 2014). The motivational part of serious game draws back on the learning part of serious games and relates to the evaluation framework of *motivation towards digital game-based learning*, in this case serious games. Applied to the current study, it therefore can be expected that self-determined motivation has effects on knowledge improvements.

## Adapted Model

Since this current study's research objective is to conduct an effect evaluation, it applies to the systematic evaluation framework by All et al. (2015). In this current study an adapted version of the systematic evaluation framework by All et al. (2015) is created and accordingly applies to serious games. Whereas the original framework serves as guiding structure, the underlying mechanisms are further explained by means of learning experiences, situational interest, the EGameFlow scale as well as the self-determination theory. The learning outcomes of the adapted framework include 1) *situational interest*, the temporary interest in a topic. This interest, for example in nutrition is triggered by an environmental factor as the serious game. 2) *Performance* is the process of gaining knowledge about nutrition during game play and 3) *transfer* is the application of learned content in real world settings, thus the adaptation to nutrition behavior. This personalized learning experience stimulates the interest of a person (see backward arrow in Figure 2). As *transfer* relates to behavioral change and this study will not focus on behavioral change, it is marked grey in Figure 2. The motivational outcomes include 1) the *game experience* (initially referred to enjoyment, by All et al. (2015)). This is split into two factors. First, in *game flow*, it is how much an individual enjoys playing the game and second, the *actual game play* (Figure 2). *Actual game play* is added to the framework and describes the maximum of reached levels in the game. This reflects how willing an individual is to play the game. Also part of the motivational outcomes is 2) *self-determined motivation*, the intrinsic motivation in making use of the instructional medium of a serious game (Figure 2). The efficiency outcomes are also marked grey in Figure 2, as this is not in the scope of this study; yet, for a complete overview of evaluating serious games it is important to include efficiency outcomes, since it indicates the reach of the serious game.

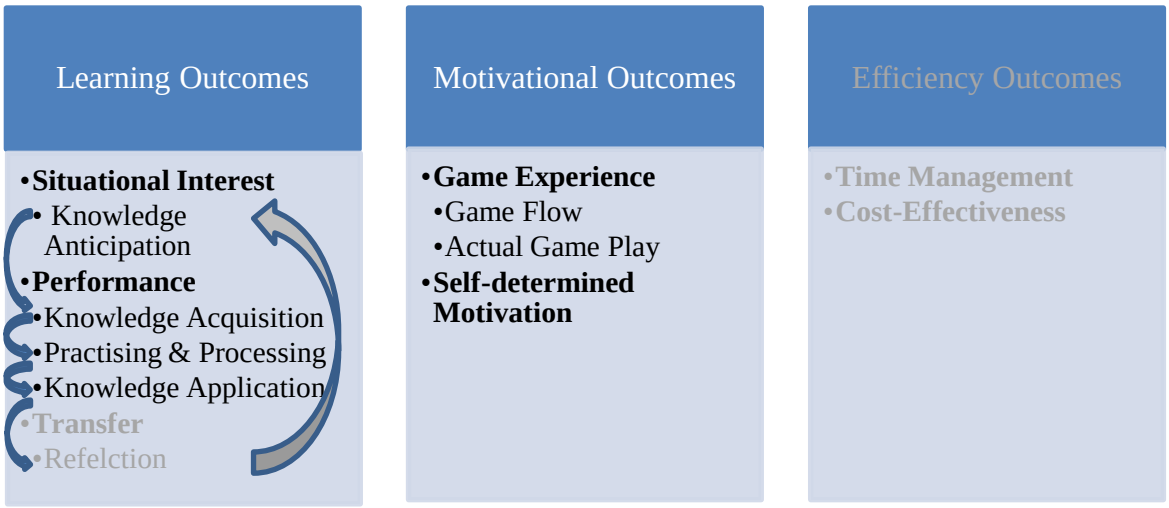



**Figure 2. Adapted Framework for Assessing Effectiveness of Serious Games Based on All et al. (2015), Abdul Jabbar & Felicia (2015) & Fu et al. (2009).**

## Hypotheses

In order to answer the sub research questions and the main research question of this study 'Is the serious game King of FoodLand effective in improving nutrition knowledge among Dutch speaking adults, and are motivational factors, related to the game influencing the effectiveness?' the following hypotheses were formulated.

The first sub research question 'Does King of FoodLand lead to an improvement of nutrition knowledge among Dutch speaking adults?' was answered by testing the following hypothesis:

- **Hypothesis 1:** Participants will have greater nutrition knowledge after playing the serious game King of FoodLand.

In order to check whether participants' self-determined motivation influences the effectiveness, the following hypothesis is part of the third research question 'Does King of FoodLand motivate Dutch speaking adults to play the game and to potentially learn about nutrition?'. This is based on research, which reveals that individuals who are intrinsically motivated are more likely to be stimulated for learning and thus show higher levels of performance (All et al., 2014).

- **Hypothesis 2**: The effects on knowledge are predicted by self-determined motivation.

In order to answer the second sub research question 'Does the game experience of Dutch speaking adults determine the effectiveness of King of FoodLand?' the following hypothesis is tested. It assesses whether participants' game experience is related with the effects on knowledge. This relates to 2) the degree to which an individual is in a game flow state and 1) actual game play, being operationalized as the maximum of reached levels in the game. This is based on research, which indicates that (game) flow enhances learning (Brockmyer et al., 2009).

- **Hypothesis 3:** The effects on knowledge are predicted by game experience.

In order to completely answer the third sub research question 'Does King of FoodLand motivate Dutch speaking adults to play the game and to potentially learn about nutrition?' four additional hypotheses complement the second hypothesis and are based on the following research results. It is assumed that motivation to make use of a serious game influences game experience, since research indicates that individuals who are intrinsically motivated have higher levels of enjoyment (All et al., 2014) and can experience (game) flow state (Brockmyer et al., 2009). Therefore, two hypotheses (hypothesis 4/ hypothesis 5) are tested, relating to the game experience, thus the game flow and the actual game play, meaning the maximum of reached levels. In addition, it is tested whether the effects of motivation on knowledge gain are mediated through game experience. Furthermore, situational interest and motivation are closely related, as situational interest can influence an individual's intrinsic motivation (Schraw et al., 2001). Yet, research also shows that intrinsically motivated individuals have higher levels of interest (All et al., 2014). Therefore, an association between both concepts is measured. Since this study tests the short-term effects of the serious game on proximal factors,

personal interest is not tested as it only changes slowly and over time. In comparison, situational interest is tested after exposing participants to the intervention, as it measures 'spontaneous' interest.

- **Hypothesis 4**: Game flow is predicted by self-determined motivation.
- **Hypothesis 5**: Actual game play is predicted by self-determined motivation.
- **Hypothesis 6**: The effects of self-determined motivation on the effects on knowledge are mediated through game experience.
- **Hypothesis 7**: Self-determined motivation is associated with situational interest in nutrition.

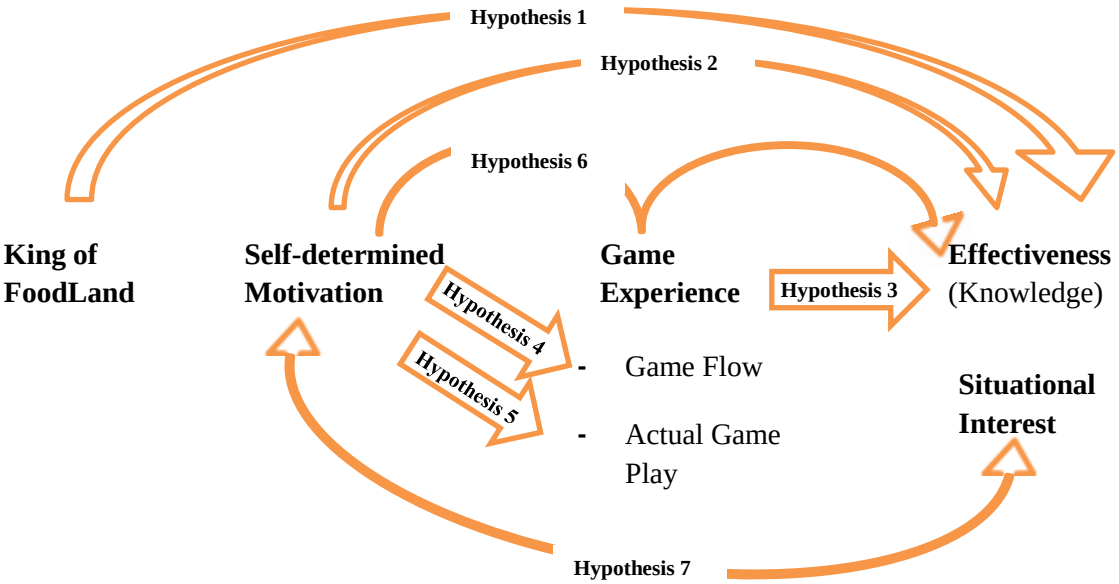



**Figure 3. Schematic Overview of Hypotheses.**

# Methods

## Participants

In order to reach participants, social media sites, such as Facebook, Twitter and LinkedIn and the digital forum of a Dutch woman magazine, called 'vriendin.nl' were used as recruitment platforms. A convenience sample was invented in order to reach as many participants as possible. Moreover, people were encouraged to like and share the participation invitation online on social media (Appendix I). Participants were able to win one out of six iTunes gift cards of 15 euros and increased their chances to win, when they publicly shared the participation invitation on social media.

Since King of FoodLand is developed for adults, only participants, aged 18 years or older were included in this study. In order to ensure a high number of participants, no upper age limit was defined. As the test version of the game included among others Dutch food products and Dutch questions, a prerequisite was the ability to read and understand Dutch. In addition, participation in this study was limited to individuals in possession of, or access to an Apple device. This included users with an iPhone, iPad or iPod touch with an iOS 8 (operating system of Apple) update or higher as the test version of King of FoodLand must be run by the app test program called TestFlight, which only allows for the latest iOS software.

Inclusion criteria:

- Individuals aged 18 years or older
- Individuals with the ability to read and understand Dutch
- Individuals possessing or having access to an Apple device (iOS 8 or higher)

In total, 42 participants were assessed for eligibility. Thirty-six participants successfully registered for the study, of those 31 participants started the study. After sample correction and issues of retention, the final sample size included 20 participants, who completed the study. All participants were asked to sign a declaration about being informed about the study's aim. Sixteen participants successfully signed the declaration of the study. The researcher decided to include the four missing cases nevertheless. Survey results showed that the four participants read the study's aim. Yet, they were not able to sign the declaration due to technical problems in the survey software. Since participants have completed the study successfully, the researcher decided that it is ethically defensible to include them in the analyses, because in case participants would not have agreed on the study's aim, they would have terminated their participation. Thus, their consent was interpreted by their behavior of continuing and completing the study. Their participation was treated with confidentiality. Moreover, the analysis of the game data included 16 participants, as 16 participants registered an account in the game and thereby their game data could be tracked to their Apple ID (Figure 4). Of the whole sample of 20 participants, the sample age ranged from 18 to 38 years (M=26.00; SD=4.58). In total, eight participants were male and twelve participants were female, thus a 40%-60% ratio. The main nationality was Dutch (N=14; 70%). Of the

remaining 30% (N=6), five participants were from Germany and one participant was from Sweden. One Dutch participant was from the second generation, as his mother is from Burkina Faso. One participant, who is not born in the Netherlands, has a Dutch father. The total sample, which completed the pre-test, as well as the post-test survey, included 20 participants. Seventy percent (N=14) completed a higher educational level, 20% (N=4) a moderate educational level, 10% (N=2) a lower educational level.

## Design and Procedure

In this study a one-group pre-test/post-test design was conducted, which allows for a within-subjects comparison. Since the nutrition-related serious game King of FoodLand had not been evaluated thus far, this study conducted a first evaluation, by means of a quasi-experimental design without a control group (Figure 4).

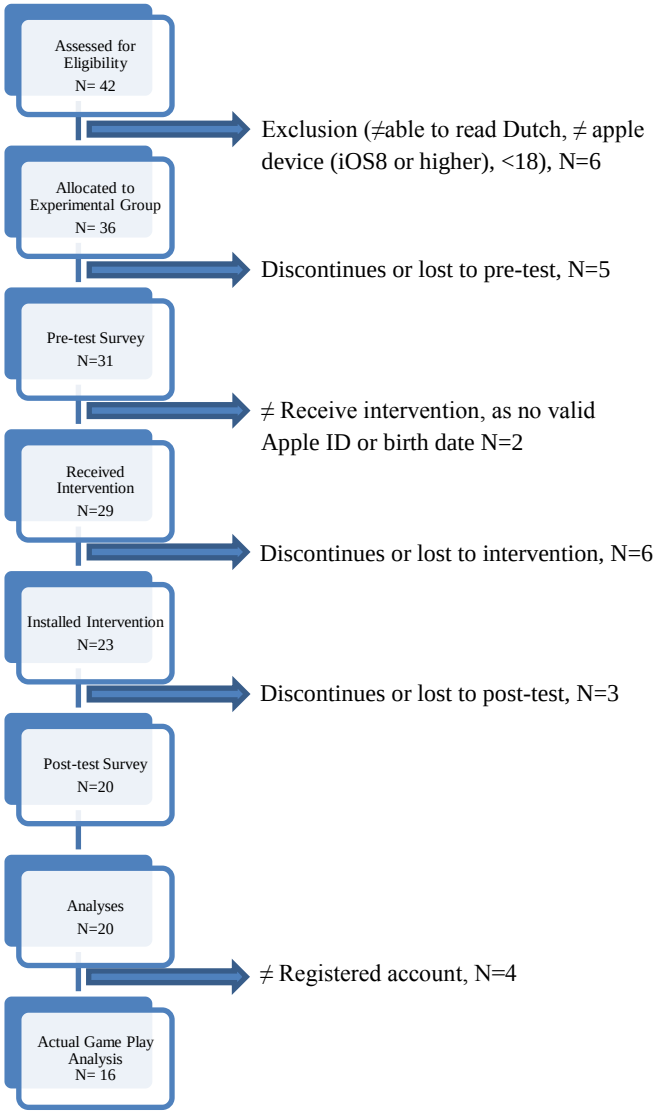



**Figure 4. Flow Diagram Scheme of the Study on Effectiveness of King of FoodLand.**

Once individuals made a preliminary decision to participate in the study or receive additional information, they were then invited to read the study's aim (Appendix I) and/or register for the study, by clicking on a forwarding link. The page opened after clicking on the link and included a registration site, designed in Qualtrics (online data collection software). Individuals could read the study's aim and decide whether they wanted to register, by clicking on the following page. This included several questions to automatically check whether they met the inclusion criteria. Individuals were asked to indicate whether they were 18 years of age or older, were in possession of an Apple device (iOS 8 or higher) and were able to read and understand Dutch. In addition, they were asked to indicate their Apple ID and their usual e-mail address (Appendix II). When they fulfilled the requirements, they were allowed to participate in the study. In case individuals did not meet the participation requirements, they immediately received an automatic response on the Qualtrics site, stating that they did not fulfill the criteria. The Qualtrics site was accessible from November 13th 2015 until November 27th 2015, thus, exactly two weeks to register for the study.

On November 23th 2015 the first e-mail was sent to the participants. Participants, who registered later than November 23th 2015 received the same e-mail immediately upon registration. The e-mail included a link, which directed participants to the online Qualtrics pre-test survey, when they clicked on the link. Participants were asked to complete an online survey to test their current nutrition knowledge. The knowledge test covered the nutrition concepts of the game as well as the concept of nutrition literacy. Additionally, participants were asked to fill in their demographics to control for confounding variables, in case that the sample group was rather broad. The details on how the concepts were measured are further described in the section measurements.

When participants completed the pre-test survey, they immediately received an e-mail to their Apple ID e-mail address, including a download link to the game King of FoodLand. When clicking on the link, participants were automatically directed to the App Store to download TestFlight. Thereby, the connection to the game King of FoodLand was automatically established, meaning that participants then had access to the game via their Apple device. Intermittent reminders were sent to the usual e-mail address of participants (once a week for two weeks) exactly one/two weeks, after completing the pre-test survey. The two e-mails reminded them about the possibility to play the game. The first reminder additionally included an optional request to create a King of FoodLand account in the game. Thereby, the data, gathered in the game could be tracked to the participant's Apple ID, as they officially agreed on the privacy terms of Apple. The data of the game were automatically stored and accessed after the participants completed the post-test survey.

After two weeks of completing the pre-test survey, participants received an e-mail with a link to the post-test survey, designed in Qualtrics. The e-mails were sent between December 7th 2015, and December 16th 2015, depending on the date participants completed the pre-test survey. First, participants were asked to answer general questions about the intervention. This included a

manipulation check to test whether participants actually played the game. The post-test survey assessed the same knowledge test as the pre-test survey and additionally tested situational interest, self-determined motivation and game flow. The pre- and post-test surveys were accessed via a link to the online survey, which has been sent by e-mail and was compatible with mobile devices. Participants could access the link, without entering a log-in code.

In order to analyze actual game play, the game data were filtered by a data analyst. This included data about how frequent participants made use of the game.

## Intervention

In general, designed as a food quiz, players of King of FoodLand have to guess nutritional content of specific food items such as carbohydrates, vitamins, minerals or calories, by comparing various food items. One level includes approximately six to eight questions. Five levels form one level block, dealing with one particular topic, such as the first three level blocks deal with energy, macronutrients and the micronutrients of vitamins. The last level of each level block includes 12 questions. Players are asked to tap the right answer to a certain question, by choosing the picture of the correct food item. Depending on the level, players must choose between two to four response options. A hint and tip module supports players with additional information in order to be able to achieve the level. Interstitials are short information boxes, which provide nutrition facts in-between levels. After giving three correct answers in a row players receive a chain bonus and an encouraging text. Besides the level blocks, there are additional level packs for players with food related health conditions such as diabetes mellitus, food allergies or kidney diseases. In addition, King of FoodLand is available in different countries/languages, and therefore includes country-specific nutritional database of the European Food Information Resource [EuroFIR] as well as country-specific food items. Via a Get Social button players can eventually interact with other players.

The intervention version of the game consisted of the first three level blocks of the actual game. This included the three level blocks 1) energy 2) macronutrients, and 3) vitamins of five levels each, whereby each level had a different aim (Appendix III). Those were included in this study since these are also the first three introducing level blocks of the actual game version King of FoodLand. Participants were informed about the fact that the game still had been in development and were therefore only able to play a shorter test version. Participants could decide within the following two weeks how often they wanted to play the first three level blocks of the game. When participants downloaded the game, the app was installed on the participant's Apple device and was therefore easily accessible. The app did not automatically expire after two weeks, but could be manually deleted by participants. Thus, participants could also continue playing the game after completing the study.

## Measurement

This study surrounded a pre-test/post-test survey design, which included items to measure the following concepts of the adapted evaluation framework (Figure 2).

### Primary Outcome Measures

*Learning Outcomes - Performance - Knowledge Test*

The first part of the knowledge pre-test and post-test survey was based on the Nutrition Literacy Assessment Instrument [NLAI], invented by Gibbs (2012). In general, NLAI measures the knowledge of people on nutrition and health, macronutrients, food portions, label reading and food groups. Yet, this study only measured knowledge on macronutrients and label reading. All six multiple choice questions of the original NLAI questionnaire on macronutrients were asked in this study. Only four multiple choice questions of the original NLAI were used in this study to test knowledge on label reading, as one question has been evaluated as hard to answer (Gibbs, 2012) and one as irrelevant for this study. Also, the label of the original NLAI was replaced by a Dutch label picture in this study in order to make it relevant for Dutch participants. It showed a label of a macaroni ham cheese meal of the Dutch Jumbo supermarket. Thus in total, ten questions were included in this study's survey to test nutrition literacy and thereby basic literacy and numeracy literacy in relation to nutrition. Each correct answer received one point, whereas a wrong answer was marked with zero points. The merged variable '*Nutrition Literacy'* included the first six questions on '*Macronutrients'* and the last four questions on *'Label*'. '*Nutrition Literacy*' was measured by calculating the mean of ten items. Thus, 0-1 correct answers indicated a high likelihood of inadequate nutrition literacy; 2-3 correct answers indicated marginal nutrition literacy; and 4-5 correct answers indicated adequate nutrition literacy (Gibbs, 2012).

In order to test the impact of reading and playing with the information of the game King of FoodLand, four questions on each level block were asked. The questions were based on the questions asked in the game. This included true/false statements, whereby each right answer received one point. 'I don't know' response options were not included, as those are neither included in the game response options. The four statements about 1) energy were merged to '*Level Energy'*, 2) macronutrients were merged to '*Level Macronutrients'*, and 3) vitamins were merged to '*Level Vitamins'*. Each participant was able to reach for all three topics of the level blocks at the most twelve points or least zero points, respectively. The different scores were indicative whether participants have gained knowledge. Participants with a mean score of 0-4 points had low nutrition knowledge, 5-8 points had moderate nutrition knowledge and 9-12 points had high nutrition knowledge on the merged variable '*Knowledge'*. In addition, the variable '*Knowledge Gain'* was merged, by subtracting '*Knowledge'* (pre-test) from '*Knowledge'* (post-test). This variable indicated whether participants gained knowledge, by means of the intervention.

In addition, two irrelevant nutrition questions were asked. Those were included in order to control for the knowledge outcomes, acquired in the game. It was expected that the answers on those two questions would not improve, since those were not addressed in the game. These included true/false statements, which could be answered by two response options. 'I don't know' was not included, as the game also did not offer this response option. These two questions were extracted from the questionnaire by van Huysduynen (2014). Both were merged to '*Knowledge Control'*.

In order to differentiate between the knowledge outcomes, measured in the pre-test and post-test, the measurement time of the pre-test or post-test are in the following explicitly stated in parentheses.

## Secondary Outcome Measures

*Learning Outcomes - Situational Interest*

Situational interest was tested with eight items on a 5-point Likert scale (1=not at all, 5=very much), whether participants strongly (dis)agree that the intervention triggered situational interest about nutrition. It was tested by means of the Sources of Interest Questionnaire by Schraw (1997). When designing the survey for this study all concepts of the original questionnaire were included: coherence (clarity and information organization), information completeness (sufficient amount of information), topic familiarity (prior knowledge), suspense (attention), thematic complexity (multiple meanings and interpretations), and vividness (exciting details). Cronbach's alpha of the original questionnaire were respectively .81, .71, .78, .72, .66 and .69 (Schraw, 1997). The survey of this study was adapted to the current topic of nutrition information in games, since the original questionnaire applies to texts. Therefore, several items as four coherence items, one vividness item, four thematic complexity items, two topic familiarity items, one informational completeness item and two suspense items were removed, since it applied highly to texts and not to games. After calculating Cronbach's alpha ($\alpha$=.66) and conducting an exploratory factor analysis by means of a principal component analysis, three items were additionally removed as situational interest was expected to be one factor. Therefore, one thematic complexity item was removed (factor loading=.15), and two topic familiarity items about knowing the information (factor loading=.14) and knowing the topic (factor loading=-.13) were removed. As the remaining included concepts of coherence (3 items) information completeness (2 items), suspense (1 item), and vividness (2 items) included only a few items for each concept, all concepts were merged to one variable, measuring '*Situational Interest'* (Eigenvalue [EEVA]=3.38; Percentage of Explained Variance [PEV]=30.74). Situational interest was calculated by the mean score on a 5-point Likert scale with a sum of eight items. Thereby, Cronbach's alpha increased from $\alpha$=.66 to $\alpha$=.76.

Additionally, participants were asked to report on confounding variables, that is 1) whether they informed themselves about diet/nutritional information since the start of the intervention (1 item) or 2) whether they got informed by peers (1 item) (Appendix V). This indicated whether participants

learned about nutrition information, parallel to the intervention. Thereby, it could be checked whether possible learning outcomes were related to the intervention or rather to external influences.

*Motivational Outcomes - Self-Determined Motivation – Self-Determination Theory*

Motivation towards the serious game King of FoodLand was assessed with eight items on a 7-point Likert scale (1=not at all true, 7=always true). This test was based on the self-determination theory and covered the original concepts of interest, perceived competence and perceived choice to measure individual's intrinsic motivation. The items were based on the validated questionnaire 'Intrinsic Motivation Inventory' and were adapted to the current topic of games (Deci & Ryan, 1994). After calculating Cronbach's alpha (α=.82) and conducting an exploratory factor analysis by means of a principal component analysis, two items have been removed. One item of the concept perceived choice about feeling obliged to play the game (factor loading=.28) and one item of the concept perceived competence about feeling as a nutrition expert (factor loading=.35) have been removed. Therefore, Cronbach's alpha increased (α=.86) and all eight items were merged to one variable, measuring participant's total '*Self-determined Motivation*' towards the serious game King of FoodLand (EEVA=4.39; PEV=43.87) and representing the mean score of all eight items on a 7-point Likert scale.

*Motivational Outcomes - Game Experience*

1) Actual Game Play

The gathered data of the game were analyzed in order to test actual game play. Therefore, data were filtered about which maximum level a participants reached, indicating whether she/he was motivated to play the game. Thereby, it could be estimated whether the '*Maximum of Reached Levels*' determined the success of learning.

2) Game Flow

Since it was tested whether participants were in a game flow state, participants were asked to rate nine items on a 7-point Likert scale (1=not agreeing, 7=totally agreeing), based on concepts of immersion, challenge and autonomy of the EGameFlow scale. Even though a total testing of the EGameFlow scale would be interesting, due to the survey's length only items which were based on the three concepts were tested, as those are crucial according to the game flow definition. The EGameFlow scale has already been tested for validity and reliability (Fu et al., 2009). However, it was adapted to the current topic, as some items were not relevant to this study. After calculating Cronbach's alpha (α=.82) and conducting an exploratory factor analysis by means of a principal component analysis, one item has been removed about a tip feature supporting the player (factor loading=.11). Therefore, Cronbach's alpha increased (α=.84) and the nine items were merged to the variable '*Game Flow*' (EEVA=4.11; PEV=41.14) to calculate the mean score of game flow.

*Demographics*

Demographics were split in general demographics, as age (calculated from birth date), sex and three questions checking participant's nationality, generation and the migration generation of mother and father (Appendix V) (GGD Rotterdam-Rijnmond, 2015). To assess the educational level of the participants, they had to indicate their highest attained educational level. The education categories were based on the classification of the Dutch central bureau for statistics (Centraal Bureau voor Statistiek, 2006) (Appendix II). Primary school (first category) and lower general secondary education (second-fourth category) were classified as a) lower educational level. The intermediate vocational education and higher secondary or pre-university education (fifth-eighth category) were classified as b) moderate educational level. Higher vocational education and university (ninth-tenth category) were classified as c) higher educational level. Income was not included in this study, as it was indicated to be a sensitive issue. Furthermore, four questions checked whether participants did the shopping themselves, whether they followed particular dietary rules, kept to a diet and if so, which one. Those items were based on the Dutch questionnaire of LifeLines, which conducted research about healthy ageing (see: http://docplayer.nl/9084317-Vragenlijst-1-deel-2-voor-deelnemers-van-65-jaar-en-ouder-lifelines.html). Demographics also included participant's Apple ID, in order to be able to link the game scores to the knowledge pre- and post-test results (Appendix V).

*Manipulation Check*

In order to check whether participants played the game, thus whether the intervention was successfully a '*Manipulation Check*' was part of this study and involved two questions. One question interrogated the amount of food groups participants were exposed to. Thus, for this question participants had to look on all levels and understand that three level blocks were core to the intervention's game version, namely 1) energy, 2) macronutrients and 3) vitamins. The other question asked in which color frame the information was provided. This question checked in general whether participants have opened the game at all. The question checked whether the game was in black-and-white or in color, whereby the latter was the correct answer. Each right answer received one point; a wrong answer was valued with zero points (Appendix V).

Table 1 summarizes all merged variables in order to provide an overview on variable names and whether those are tested in the pre-test or in the post-test survey.

**Table 1. Merged Variables.**

| Outcome | Concept | Variable Name | Pre-test | Post-test | Alpha |
|---|---|---|---|---|---|
| ***Primary*** *Outcome Measures* | | | | | |
| *Learning Outcomes* **Performance** | Nutrition Literacy Assessment Instrument | Macronutrients<br>Label Reading<br>Nutrition Literacy | X<br>X<br>X | X<br>X<br>X | |
| | Information in Game | Level Energy<br>Level Macronutrients<br>Level Vitamins<br>Knowledge<br>Knowledge Gain | X<br>X<br>X<br>X | X<br>X<br>X<br>X | |
| | Control | Knowledge Control | X | X | |
| ***Secondary*** *Outcome Measures* | | | | | |
| *Learning Outcomes* **Situational Interest** | Sources of Interest Questionnaire | Situational Interest | | X | α=.76 |
| *Motivational Outcomes* **Self-determined Motivation** | Intrinsic Motivation Inventory | Self-determined Motivation | | X | α=.86 |
| *Motivational Outcomes* **Game Flow** | EGame Flow Scale | Game Flow | | X | α=.84 |
| *Motivational Outcomes* **Actual Game Play** | | Maximum of Reached Levels | | | |
| **Manipulation Check** | | Manipulation Check | | X | |

## Data Analysis

Data were analyzed using IBM SPSS 23.0 for Windows.

*Hypothesis 1*

The knowledge part of the pre-test and the post-test survey was compared between participants. Therefore, a paired sample *t*-test (within group) was conducted, after checking for normal distribution among knowledge variables. The dependent variable was the knowledge part of the pre-test as variable 1 and the knowledge part of the post-test as variable 2. In addition, a simple regression tested whether knowledge on the pre-test and nutrition literacy on the pre-test as independent variables predicted the dependent variable knowledge gain. Thereby, it was determined whether prior knowledge affected knowledge gain scores.

*Hypotheses 2/3/4/5/6/7*

In order to establish correlations and since not all variables were normally distributed, a Spearman's rank-order correlation table was run for the primary outcome measures of knowledge gain, knowledge on the pre-test, knowledge on the post-test and on the secondary outcome measures of situational interest, self-determined motivation, game flow, maximum of reached levels, age, gender and education. Dietary rules were excluded of the correlations, as only two individuals indicated following particular dietary rules. Thereby, a significance level was set at 5%. A simple regression analysis was conducted with knowledge gain as the dependent variable and self-determined motivation as independent variable. A multiple regression analysis was conducted with knowledge gain as the dependent variable and game experience, thus game flow and maximum of reached levels as

independent variables. Furthermore, two separate linear regression analysis were conducted with game experience as dependent variable and self-determined motivation as independent variable. Thus, one was conducted with maximum of reached levels and one with game flow as dependent variable. In addition, by means of a multiple regression analysis it was tested whether the effects of self-determined motivation on knowledge gain were mediated through game experience. Therefore, knowledge gain was the dependent variable and self-determined motivation, as well as both game experience variables, maximum of reached levels and game flow were on the independent variable. Thereby, it was expected that self-determined motivation influenced knowledge gain. Further, it was expected that Beta scores would decrease with self-determined motivation, and both mediators of game flow and actual game play as independent variables in comparison to the regression analysis of only self-determined motivation as independent variable, according to the mediation test (Baron & Kenny, 1986).

# Results

## Description of Participants

With regard to the participant's nutrition background, 80% (N=16) indicated not being familiar with nutrition that is comparable to a nutrition-related profession or educational program. Ninety percent (N=18) indicated to do the shopping by themselves. Two participants indicated to follow particular dietary rules, as both pointed out to be flexitarian, meaning to be a 'part-time' vegetarian. Thus, in total 90% indicated not to follow dietary rules. In total, three participants (15%) stated to keep to a diet, whereas one participant specified the aim of losing weight and following the diet "leven lang fit" (lifelong fit), meaning not combining proteins with carbohydrates. The other participant specified the aim of losing weight and eating healthy, by following the diet "raw food" and being a flexitarian. The third participant adapted his/her diet as he/she was participating meanwhile in gut research and was therefore following the "Paleo" diet, which is based on eating meat, fish, vegetables, fruit and nuts.

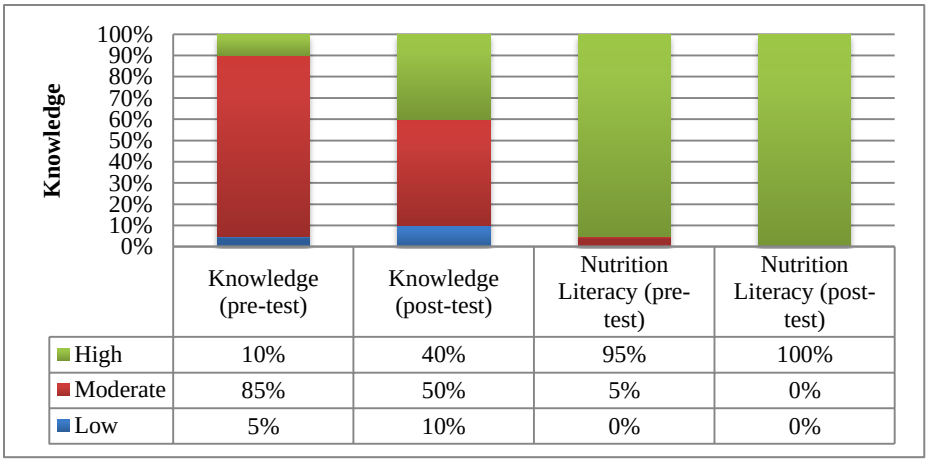
According to the manipulation check, participants played the game, as the two questions of the manipulation check showed that 80% (N=16) answered both questions correctly. Thus, participants knew that energy, macronutrients and vitamins were the topics of the three level blocks and that the game was provided in color. The remaining 20% (N=4) answered only the second question correctly that the game was provided in color.

## Primary Outcome Measures

*Learning Outcomes - Performance – Knowledge Test*

Most of the participants (95%; N=19) already had adequate nutrition literacy in the pre-test, scoring four to five correct answers (out of the mean of 10 questions). In the post-test measurement all participants reached adequate nutrition literacy (Figure 5). The paired sample *t*-test pointed out that participant's nutrition literacy had not significantly increased after playing the game (Table 2). In detail, nutrition literacy on macronutrients had not changed significantly from the pre-test to the post-test ($p>.99$). In addition, nutrition literacy on label reading did not change significantly from the pre-test to the post-test ($p>.99$) (Table 2).

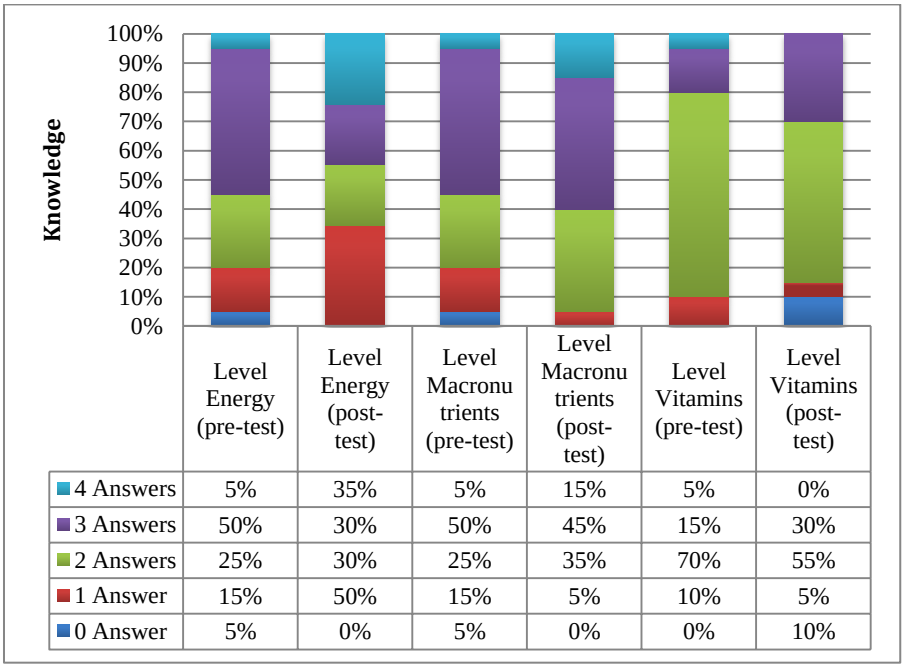
Analyses showed that participants had on average moderate nutrition knowledge in the pre-test and post-test, since five to eight points (1 point for each right answer; in total 12 questions) indicated moderate nutrition knowledge (Figure 5). The paired sample *t*-test revealed that participants had on average significantly ($p=.047$) greater knowledge after playing the game King of FoodLand than before playing the game (Table 2). According to Cohen's *d*, which is the magnitude of observed effects, the current study showed a medium effect size ($d=0.49$) (Field, 2013). In detail, participants scored significantly higher at post-test on knowledge about energy (addressed in the first level block) than in the pre-test ($p=.03$). Participants did not score significantly higher on knowledge about macronutrients or vitamins, taught in the second and third level block (Table 2).




| | Knowledge (pre-test) | Knowledge (post-test) | Nutrition Literacy (pre-test) | Nutrition Literacy (post-test) |
|---|---|---|---|---|
| High | 10% | 40% | 95% | 100% |
| Moderate | 85% | 50% | 5% | 0% |
| Low | 5% | 10% | 0% | 0% |

**Figure 5. Frequencies of Knowledge and Nutrition Literacy.**

Moderate nutrition knowledge (pre-test) was high, but decreased (post-test). However, high nutrition knowledge (post-test) increased. Low nutrition knowledge was not common among participants (pre-test & post-test) (Figure 5). With a focus on knowledge about the energy level, analyses showed that answering all four questions correctly increased from the pre-test to the post-test. Answering three questions correctly dropped as well as giving no correct answers, whereas answering one or two questions correctly increased from the pre-test to the post-test. With regard to knowledge about the macronutrients level, results showed that answering either two or four questions correctly increased, whereas giving no correct, one or three correct answers dropped from the pre-test to the post-test. Obviously, most of the participants scored low on answering questions about the vitamin level correctly, which even dropped further in the post-test. For example, giving no correct answers increased, whereas giving one, two or four correct answers decreased. Answering three correct answers however increased (Figure 6).




| | Level Energy (pre-test) | Level Energy (post-test) | Level Macronutrients (pre-test) | Level Macronutrients (post-test) | Level Vitamins (pre-test) | Level Vitamins (post-test) |
|---|---|---|---|---|---|---|
| 4 Answers | 5% | 35% | 5% | 15% | 5% | 0% |
| 3 Answers | 50% | 30% | 50% | 45% | 15% | 30% |
| 2 Answers | 25% | 30% | 25% | 35% | 70% | 55% |
| 1 Answer | 15% | 50% | 15% | 5% | 10% | 5% |
| 0 Answer | 5% | 0% | 5% | 0% | 0% | 10% |

**Figure 6. Frequencies of Knowledge about Energy, Macronutrients and Vitamins.**

Furthermore, the paired sample *t*-test showed that participants did not significantly increase their knowledge on the two knowledge control questions, which controlled for the knowledge outcomes, compared to the pre-test (Table 2). Thus, two questions which were also not addressed in the game did not significantly increased in the post-test.

**Table 2. Paired Sample *t*-Test, Testing for Differences between Pre- and Posttest in Knowledge Variables.**

| | Measurement Time | Mean | SD | SE | t | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| **Nutrition Literacy** | Pre-test | 4.45 | 0.74 | 0.17 | | |
| | Post-test | 4.45 | 0.43 | 0.10 | 0.00 | >.99 |
| | | | | | | |
| **Macronutrients** | Pre-test | 5.20 | 0.95 | 0.21 | | |
| | Post-test | 5.20 | 0.77 | 0.17 | 0.00 | >.99 |
| | | | | | | |
| **Label Reading** | Pre-test | 3.70 | 0.73 | 0.16 | | |
| | Post-test | 3.70 | 0.66 | 0.15 | 0.00 | >.99 |
| | | | | | | |
| **Knowledge** | Pre-test | 6.85 | 1.46 | 0.33 | | |
| | Post-test | 7.70 | 1.98 | 0.44 | -2.13 | **.047*** |
| | | | | | | |
| **Level Energy** | Pre-test | 2.35 | 0.99 | 0.22 | | |
| | Post-test | 2.95 | 0.95 | 0.21 | -2.35 | **.03*** |
| | | | | | | |
| **Level Macronutrients** | Pre-test | 2.35 | 0.99 | 0.22 | | |
| | Post-test | 2.70 | 0.80 | 0.18 | -1.79 | .09 |
| | | | | | | |
| **Level Vitamins** | Pre-test | 2.15 | 0.67 | 0.15 | | |
| | Post-test | 2.05 | 0.89 | 0.20 | 0.44 | .67 |
| | | | | | | |
| **Knowledge Control** | Pre-test | 1.75 | 0.44 | 0.10 | | |
| | Post-test | 1.65 | 0.49 | 0.11 | 0.70 | .49 |

Note: N=20

## Secondary Outcome Measures

*Learning Outcomes - Situational Interest*

Participants reported moderate situational interest (Table 3). Fifty-five percent (N=11) agreed with the statements of situational interest (scoring a 4 or higher on the 5-point Likert scale). Items of situational interest showed high standard deviations. In particular, participants were neutral that levels in the game flowed smoothly (M=3.15; SD=1.04), information was memorable (M=3.00; SD=0.91) and grabbed their attention (M=3.50; SD=0.89). Participants were slightly positive that information in the game was clearly formulated (M=3.85; SD=0.59), clearly presented (M=3.95; SD=0.39), was vivid (M=3.75; SD=0.91) and made sense (M=3.70; SD=0.66). They disagreed that information was complete (M=2.90; SD=0.85). Further, results showed that participants have not been influenced by information they searched on themselves (M=2.25; SD=1.07) or received from fellows (M=2.15; SD=1.04) (Appendix V).

*Motivational Outcomes - Self-determined Motivation*

Participants were generally motivated to play King of FoodLand (Table 3). However, it must be mentioned that items of self-determined motivation showed high standard deviations, ranging from 0.77 to 1.29. In particular, 10% (N=2) rated the statements of self-determined motivation on a neutral scale (scoring a 4 on the 7-point Likert scale), whereas 75% (N=15) rated self-determined motivation as often to almost always true (scoring a 5 or higher). In total, 15% (N=3) were highly motivated (scoring a 7). In detail, results showed that participants were neutral on their performance in the game (M=4.90; SD=1.29). However, participants indicated that they disagreed with the statements that they had no other choice than playing the game (M=6.00; SD=0.86) or that they lost their attention (M=5.59; SD=1.15). Furthermore, participants indicated that they were willing to play the game (M=5.60; SD=1.00), understood the information of the game (M=5.70; SD=0.92), found it interesting (M=5.20; SD=1.28), entertaining (M=5.05; SD=0.83) and fun (M=5.35; SD=1.18) (Appendix V).

*Motivational Outcomes - Game Experience*

1) Actual Game Play

The data of the game showed that of the 16 participants, who registered an account in the game, it has been shown that the average number of reached levels was 13 out of 15 (SD=5.04) (Table 3). More specifically, 69% (N=11) reached level 15, 15% (N=3) only reached the first level block about energy, whereof 5% (N=1) only reached level three and 10% completed level five. Ten percent (N=2) reached the second level block about macronutrients. Specifically, 5% reached level six and 5% (N=1) reached level ten. It is important to take into consideration, that only a number of participants have registered an account (N=16).

2) Game Flow

Participants reported a neutral game flow (scoring a 4 on the 7-point Likert scale) (Table 3). In detail, 20% (N=6) reported that on average they lacked game flow. Forty-five percent (N=9) rated game flow on a neutral scale, whereas 25% (N=5) found themselves to a certain degree in a game flow. Again, it was striking that standard deviations were high for all game flow items (Appendix V). In detail, participants indicated disagreement that they felt emotionally involved (M=3.80; SD=1.47), had an altered sense of time (M=3.65; SD=1.69), became unaware of their surroundings (M=3.25; SD=1.80), temporally forgot about problems (M=3.35; SD=1.87) and disagreed that the game involved new challenges with an appropriate pacing (M=3.95; SD=1.70). Furthermore, participants had a slightly positive opinion about their involvement in the game (M=4.85; SD=1.14), were neutral whether they had control (M=4.55; SD=1.43) or whether they knew the next step in the game (M=4.30; SD=1.53). Also, they were neutral about the statement that the difficulty of challenges increased as their skills improved (M=4.60; SD=1.57) (Appendix V).

**Table 3. Descriptive Statistics of Secondary Outcome Measures of Situational Interest, Self-determined Motivation, Game Flow and Maximum Level.**

| | N | M | SD | SE | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| **Situational Interest** | 20 | 3.48 | 0.51 | 0.11 | 0.26 | 2 | 4 |
| **Self-determined Motivation** | 20 | 5.41 | 0.77 | 0.17 | 0.59 | 4 | 7 |
| **Game Flow** | 20 | 4.03 | 1.06 | 0.24 | 1.12 | 2 | 6 |
| **Maximum Level** | 16 | 12.75 | 5.04 | 1.26 | 25.40 | 3 | 17 |

## Correlation

The Spearman's rank-order correlation was run to determine the relationship between situational interest and self-determined motivation for serious games. There was a strong, positive correlation between situational interest and self-determined motivation (defined to be r=.50 or higher according to (Field, 2013)), which was statistically significant (r=.79; p=.00) (Table 4). This confirms hypothesis 7 that self-determined motivation is associated with situational interest in nutrition.

Table 4 shows that knowledge (post-test) was significantly positively correlated with knowledge about macronutrients (post-test) (r=.77; p=.00). Also, knowledge (pre-test) was significantly positively correlated with knowledge about macronutrients (pre-test) (r=.75; p=.00). Further, knowledge about energy (post-test) was significantly positively correlated with knowledge (post-test) (r=.74; p=.00). Table 4 also shows that knowledge gain was significantly positively correlated with knowledge (post-test) (r=.69; p=.001). In addition, knowledge (post-test) was significantly positively correlated with vitamins (post-test) (r=.67; p=.001) and knowledge (pre-test) was significantly positively correlated with knowledge about energy (pre-test) (r=.62; p=.00). Moreover, knowledge gain was significantly positively correlated with knowledge about energy (post-test) (r=.56; p=.01) and macronutrients (post-test) (r=.52; p=.02). Nutrition literacy, measured on the pre-test and on the post-test were significantly positively, albeit weakly correlated (r=.52; p=.02). Also, knowledge about macronutrients, measured in the pre-test and in the post-test were significantly positively, albeit weakly correlated (r=.51; p=.02). (Table 4)

In addition, the Spearman's rank-order correlation showed that the maximum of reached levels was significantly negatively, albeit weakly correlated with knowledge about energy (post-test) (r=-.50; p=.049). In general, gender was significantly negatively correlated with age (r=-.51; p=.005). Furthermore, the Spearman's rank-order correlation showed that self-determined motivation and game flow were not significantly correlated (r=.44; p=.052) and neither were knowledge about macronutrients (post-test) and age (r=-.43; p=.059) (Table 4). Yet, it is possible that the correlations could be significant with a greater sample size as *p*-values were almost significant.

Furthermore, self-determined motivation was not correlated with knowledge gain or with knowledge (post-test) (Table 4). This indicated that hypothesis 2 had to be refuted, meaning that self-determined motivation did not influence the effects on knowledge.

## Regression

A multiple regression analysis was run to predict knowledge gain from knowledge (pre-test) and nutrition literacy (pre-test). Even though, this was not part of a particular hypothesis in this study, this test was included to control whether prior knowledge affects knowledge gain scores. The variables did not significantly predict knowledge gain $F(1, 18)=0.67$, $p=.52$, $R^2=0.08$ (Table 5), indicating that participant's prior knowledge did not cause the effects on nutrition knowledge, taught in the game.

In addition, a simple regression analysis revealed knowledge gain could not be predicted by self-determined motivation $F(1, 18)=0.04$, $p=.84$, $R^2=0.00$ (Table 5), suggesting that knowledge gain was not different for participants with high self-determined motivation than for participants with low self-determined motivation. Thereby, hypothesis 2 was refuted.

Furthermore, a multiple regression analysis revealed that knowledge gain was not predicted by actual game play or game flow as stated in hypothesis 3 $F(2, 13)=0.37$, $p=.70$, $R^2=0.05$ (Table 5). This showed that neither the maximum of reached levels, nor the degree of game flow made any differences in the effects on knowledge. Thus, game experience did not influence the effects on knowledge.

In order to check hypothesis 4 and 5, whether game flow and actual game play can be predicted by self-determined motivation, two simple regression analyses were conducted. Those revealed that actual game play as dependent variable was not predicted by self-determined motivation as independent variable $F(1, 14)=0.82$, $p=.38$, $R^2=0.06$ (Table 6). This indicated that differences in self-determined motivation did not influence the maximum of levels a participant reached in the game. Therefore, hypothesis 5 was refuted. Yet, self-determined motivation was predicted by game flow as dependent variable as stated in hypothesis 4 $F(1, 18)=6.38$, $p=.02$, $R^2=0.26$ (Table 6), indicating that participant's self-determined motivation affected the game flow experience.

Hypothesis 6 stated that the effects of self-determined motivation on knowledge gain are mediated through game experience. Results showed that self-determined motivation and game experience as independent variables did not predict knowledge gain $F(3, 12)=0.24$, $p=.87$, $R^2=0.06$ (Table 5). As already no regression between self-determined motivation and knowledge gain could be detected, as well as no regression between game experience on knowledge gain (Table 5), results were supported that game experience could not predict the effects on knowledge as mediator of self-determined motivation. Yet, results showed that self-determined motivation could predict game flow (Table 6). According to the mediation test, Beta scores had to decrease in the regression analysis of self-determined motivation, game flow and maximum of reached levels on knowledge gain, in comparison

to the Beta scores of the regression analysis of only self-determined motivation on knowledge gain and mediators had to be significant (Table 5).

## Comments Made by Participants

Ten participants added additional comments to the last questionnaire. Seven participants indicated that the download, loading and updates of the game took a long time. One participant explicitly indicated that she/he would have played the game more often, if the game did not require such a long time to load appropriately. Further, one participant pointed out that the game included too many levels. Other participants suggested including an introduction to the game, explanations prior to each level and more available information about macro- and micronutrients and food products. Two participants revealed that the simplicity of the game was attractive; yet, the game could be even more interesting and fun.

**Table 4. Correlation Matrix.**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Age | - | | | | | | | | | | | | | | | | |
| 2. Gender | **-.51**** | - | | | | | | | | | | | | | | | |
| | (29) | | | | | | | | | | | | | | | | |
| 3. Situational Interest | .10 | -.05 | - | | | | | | | | | | | | | | |
| | (20) | (20) | | | | | | | | | | | | | | | |
| 4. Motivation | .08 | .14 | **.79**** | - | | | | | | | | | | | | | |
| | (20) | (20) | (20) | | | | | | | | | | | | | | |
| 5. Game Flow | .19 | -.13 | .40 | .44 | - | | | | | | | | | | | | |
| | (20) | (20) | (20) | (20) | | | | | | | | | | | | | |
| 6. Knowledge Gain | -.39 | .42 | .03 | .03 | -.04 | - | | | | | | | | | | | |
| | (20) | (20) | (20) | (20) | (20) | | | | | | | | | | | | |
| 7. Knowledge | .03 | -.18 | .07 | -.03 | -.03 | -.32 | - | | | | | | | | | | |
| (Pre-test) | (29) | (29) | (20) | (20) | (20) | (20) | | | | | | | | | | | |
| 8. Knowledge | -.37 | .23 | .06 | -.03 | .02 | **.69**** | .41 | - | | | | | | | | | |
| (Post-test) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | | | | | | | | | | |
| 9. Energy | .15 | -.02 | .05 | .29 | .22 | -.17 | **.62**** | .13 | - | | | | | | | | |
| (Pre-test) | (29) | (29) | (20) | (20) | (20) | (20) | (29) | (20) | | | | | | | | | |
| 10. Energy | -.19 | .27 | -.08 | -.09 | -.05 | **.56*** | .28 | **.74**** | .29 | - | | | | | | | |
| (Post-test) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | | | | | | | | |
| 11. Macronutrients | -.01 | -.18 | -.04 | -.31 | -.39 | -.07 | **.75**** | .36 | .15 | .05 | - | | | | | | |
| (Pre-test) | (29) | (29) | (20) | (20) | (20) | (20) | (29) | (20) | (29) | (20) | | | | | | | |
| 12. Macronutrients | -.43 | .04 | -.02 | -.16 | -.08 | **.52*** | .33 | **.77**** | -.12 | .32 | **.51*** | - | | | | | |
| (Post-test) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | | | | | | |
| 13. Vitamins | -.19 | -.01 | .21 | -.02 | .07 | -.25 | .27 | .15 | -.28 | .14 | .08 | .15 | - | | | | |
| (Pre-test) | (29) | (29) | (20) | (20) | (20) | (20) | (29) | (20) | (29) | (20) | (29) | (20) | | | | | |
| 14. Vitamins | -.26 | .17 | .28 | .28 | .14 | .41 | .34 | **.67**** | .06 | .20 | .38 | .43 | .00 | - | | | |
| (Post-test) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | | | | |
| 15. Nutrition Literacy | -.21 | .14 | .07 | .12 | -.05 | .00 | .13 | .19 | .04 | .28 | .10 | -.10 | .05 | .41 | - | | |
| (Pre-test) | (29) | (29) | (20) | (20) | (20) | (20) | (29) | (20) | (29) | (20) | (29) | (20) | (29) | (20) | | | |
| 16. Nutrition Literacy | -.31 | .06 | -.21 | -.25 | -.25 | -.06 | .14 | -.04 | .25 | .22 | .02 | -.05 | -.08 | -.11 | **.52*** | - | |
| (Post-test) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | (20) | | |
| 17. Maximum Level | -.10 | -.03 | -.02 | .14 | .31 | -.38 | .14 | -.19 | .21 | **-.50*** | -.03 | -.08 | -.03 | .22 | .14 | -.25 | - |
| | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | (16) | |

Note: In bold significant correlation coefficient at *.05 level (two-tailed), **.01 level (two-tailed).

**Table 5. Regression Analysis of Knowledge Gain.**

| | *Knowledge Gain* | | | | |
|---|---|---|---|---|---|
| | *B* | SE *B* | ß | *t* | *p* |
| **Knowledge** (Pre-test) | -0.34 | 0.29 | -0.28 | -1.17 | .26 |
| **Nutrition Literacy** (Pre-test) | 0.08 | 0.58 | 0.03 | 0.14 | .89 |
| ***R²*** | | 0.08 | | | |
| ***F*** | | 0.69 | | | |
| ***p*** | | .52 | | | |
| | | | | | |
| **Self-determined Motivation** | 0.11 | 0.55 | 0.05 | 0.20 | .84 |
| ***R²*** | | 0.00 | | | |
| ***F*** | | 0.04 | | | |
| ***p*** | | .84 | | | |
| | | | | | |
| **Game Flow** | 0.14 | 0.46 | 0.08 | 0.30 | .77 |
| **Maximum Levels** | -0.09 | 0.11 | -0.24 | -0.85 | .41 |
| ***R²*** | | 0.05 | | | |
| ***F*** | | 0.37 | | | |
| ***p*** | | .70 | | | |
| | | | | | |
| **Self-determined Motivation** | -0.15 | 0.81 | -0.06 | -0.18 | .86 |
| **Game Flow** | 0.19 | 0.56 | 0.12 | 0.34 | .74 |
| **Maximum Levels** | -0.09 | 0.11 | -0.23 | -0.79 | .45 |
| ***R²*** | | 0.06 | | | |
| ***F*** | | 0.24 | | | |
| ***p*** | | .87 | | | |

Note: knowledge gain as dependent variable – unstandardized coefficients, standardized ß-coefficient, *t*-values and *p*-values are reported.

**Table 6. Regression Analysis of Game Experience.**

| | *Maximum of Reached Levels* | | | | | *Game Flow* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *B* | SE *B* | ß | *t* | *p* | *B* | SE *B* | ß | *t* | *p* |
| **Self-determined Motivation** | 1.48 | 1.63 | 0.24 | 0.91 | .38 | 0.70 | 0.28 | 0.51 | 2.53 | **.02** |
| ***R²*** | | 0.06 | | | | | 0.26 | | | |
| ***F*** | | 0.82 | | | | | 6.38 | | | |
| ***p*** | | .38 | | | | | .02 | | | |

Note: Maximum of reached levels and game flow as dependent variable – unstandardized coefficients, standardized ß-coefficient, *t*-values and *p*-values are reported.

# Discussion

## General Conclusion

The current study revealed that participant's nutrition knowledge, taught in the game King of FoodLand partly improved during the intervention time. In particular, the study proved that knowledge about energy increased significantly among participants. Thus, it can be assumed that playing the first level block about energy possibly explains the effects on improving knowledge. One possible explanation is that the first level block was played by almost all participants, meaning they had most exposure to this part of the game. Also, the study revealed that individuals did not significantly increase their knowledge about macronutrients and vitamins. A possible drop in the number of participants in the last two level blocks might have affected the non-significant results of gaining knowledge about macronutrients and vitamins. Participants scored lowest on knowledge about vitamins of the last level block, whereas their knowledge about macronutrients still increased, though not significantly. In addition, correlations showed that knowledge about macronutrients, measured in the post-test was significantly correlated with knowledge and knowledge gain, measured in the post-test. This indicates that even though knowledge about macronutrients did not significantly increase, it contributed to the overall knowledge gain. Thus, it is questionable whether the decrease of knowledge gain from one level block to another level block is influenced by the drop of participant numbers during game play, by a decrease of interest in the topics from energy to vitamins or by other factors. Furthermore, results revealed that knowledge gain was neither influenced by participant's prior knowledge, nor by his/her nutrition literacy. The results showed that in general participants were highly nutrition literate and had moderate nutrition knowledge, which was addressed in the game. Participant's nutrition literacy did not significantly increase during the intervention time. As the nutrition literacy questions were basic and were not part of the game, it was expected that nutrition literacy would not significantly increase. As the results showed that King of FoodLand was partly effective on individual's nutrition knowledge, it is interesting to examine which motivational factors shaped the effects on nutrition knowledge.

The study showed that participants assessed King of FoodLand as a motivating medium to learn about nutrition, meaning that participants' self-determined motivation was high. Yet, having self-determined motivation to play the game was not associated with increases in participant's knowledge. It was expected that individuals are more open towards new information when they are intrinsically motivated, but the results did not confirm this idea. Even though self-determined motivation seemed high which was positively associated with the experiences of game flow, game flow in general was at the low end. Also, game flow was not associated with gains in nutrition knowledge. A possible explanation is that participants had technical issues when loading the game on their device, possibly inhibiting them to enter a game flow mode. Moreover, the study revealed that self-determined motivation could be partly predicted by participants' game experience. In particular, the study showed

that game flow could be predicted by self-determined motivation, which is in line with research that reveals that people can experience (game) flow when they are engaged in an intrinsically rewarding activity (Brockmyer et al., 2009). However, the maximum of reached levels did not predict participants' self-determined motivation. Situational interest and motivation were significantly positively correlated. As both concepts were measured on the same measurement time, no conclusions can be drawn whether one predicts the other. Yet, results obviously show that the way information about nutrition is presented links well with self-determined motivation. However, it has to be stated that situational interest was generally assessed on a neutral scale. Knowledge gain could not be predicted by self-determined motivation and was therefore also not mediated by game experience. This shows that the overall model of this study does not explain the effects on knowledge, when playing King of FoodLand. Although former research declared motivation to be a driving factor in enhancing learning (Abdul Jabbar & Felicia, 2015), the current study showed no decisive motivational factors influencing the effects on knowledge, even though the current study contained high self-determined motivation among participants. In addition, the maximum of reached levels was negatively associated with knowledge about energy (post-test). Individuals who played all levels were exposed to more information and therefore may have found it harder to recall the information they learned in the first level.

To sum up, individuals increased their nutrition knowledge during the intervention time. Whereas the highest knowledge gain was noticed about energy, knowledge about macronutrients still increased, yet dropped with knowledge about vitamins, taught in the last level block. Even though individuals were motivated to play the game, motivational factors such as self-determined motivation, actual game play or game flow did not predict the effect on nutrition knowledge. However, self-determined motivation did predict game flow and was also correlated with situational interest. In summary, it can be concluded that in the current study nutrition knowledge significantly increased. Yet, whether these effects can be explained by the activity of playing King of FoodLand still remains unclear and cannot be attributed to the game, at least not in the current study. Whereas results showed that participants had a high self-determined motivation, it is still undetected which motivational factors are potentially decisive. For example, it is likely that other motivational factors such as playing the game more frequently could possibly predict or explain the effects on knowledge (DeSmet et al., 2014).

## Strengths and Limitations

The current study included a number of strengths, which support the results of this study such as testing in a real-world setting. Yet, several limitations of this study need to be acknowledged as well such as the lack of a control group. In terms of the internal validity of this study the following strengths and limitations exist. The manipulation check indicated that all participants opened the game and most participants were exposed to the intervention. Yet, to what extent participants were exposed to the intervention cannot be analyzed for the whole sample, since not every participant registered an

account in the game. Therefore, the game data could not be tracked for each participant. In addition, since a lot of missing values existed in the game data, further variables of actual game play such as frequency and duration could not be included.

Furthermore, the study tested the effects of the intervention, by measuring the pre-test post-test differences. Thus, two measurements were included and were additionally complemented by game data. However, a control group was not included in this study. Thereby, results cannot be attributed to the intervention and only give an indication on possible effects, which occurred during the intervention time. The study highly relies on the answers of participants, thus self-reported data. This is prone to socially desirable answers. The requirement of leaving participants the opportunity to stop the survey whenever they wanted however ensured that participants did not answer the questions desultorily due to an obligation. A strong element of the study is that the game data contributes to the results, as those complement the study with data about participant's actual behavior. For example, self-determined motivation was tested by means of a survey, but motivation to actually play the game, thus actual game play was assessed by means of the game data.

In addition, situational interest, thus the spontaneous interest, which occurs between a person and an activity was measured rather late in this study. When participants were permitted access to the game, they could decide when they wanted to play the game, before completing the post-test survey two weeks after. Thus, it is possible that participants immediately played the game, but completed the post-test survey exactly two weeks later. In this case, it is problematic to measure participant's situational interest as it did not occur spontaneously after exposing the participant to the intervention. However, this study set-up does reflect the actual interest of individuals to play the game, as free choice was promoted and no further instructions were obliged to individuals. An additional limitation of this study, relating to the pre-test and post-test surveys involves the shortened versions of existing and validated questionnaires. The shortage and translation from English to Dutch impedes a threat to the internal validity.

This study hypothesized a causal relationship between variables. Due to the correlational nature of the study, however, no conclusions about causality can be drawn. For example, it is still unclear whether self-determined motivation influences situational interest or vice versa. Also, it was tested that self-determined motivation triggers game experiences, which influences effectiveness. Even though the model of this study was based on past research, it is still possible that game experience might trigger situational interest, which influences self-determined motivation and lead to the effectiveness on knowledge gain. Moreover, the model examined whether self-determined motivation influences game flow. Both variables were measured at the same time period of the post-test. Measuring a relationship between both concepts, without considering time order can impede the internal validity. Thus, the study misses longitudinal data.

A definite strength of this study is that participant's knowledge gain and motivation was tested in a real-world setting. This means that participants were able to play the game on their personal device whenever they were motivated to do so, but were also given the opportunity to stop the study whenever they wanted to. This study set-up supports the measurement of motivational factors and indicates how the game certainly will be played when it is released. Since standard deviations were often high, it is likely that some individuals enjoyed playing the game, whereas other did not. This result may be influenced by the fact that occasionally the game had technical difficulties to fully load. The technical problems were explicitly indicated by some participants of this study. A limitation, which is closely related to measuring motivational factors involves that participants only had two weeks to play the game. Research among people from the United States shows that mobile health apps are usually used at least once per day (Krebs & Duncan, 2015). Yet, no conclusions can be drawn whether the time frame of two weeks was appropriate to measure actual effects. The game only involved a limited amount of 15 levels. Participants had as much time as they needed to answer the questions; yet, received a time bonus when they answered quickly. Since one level approximately includes six to eight questions, one level block includes approximately 30 to 40 questions and 15 levels respectively 90 to 120 questions. Even though participants could freely choose how often they wanted to play the levels, it still remains questionable, whether two weeks is an appropriate time frame to play 15 levels.

With regard to the external validity of this study, one weakness is that participants were addressed by social media platforms. Furthermore, only participants, who were in possession of an Apple device, were able to participate in this study. Moreover, most participants of this study had a high education. Hence, the study's results are difficult to generalize to the wider population and are only generalizable to people, who are active on social media and who are in possession of an Apple device. In addition, the small sample size in this study (N=20) limits its generalizability. Forty-two potential participants were assessed for eligibility and during the study 22 participants dropped-out. Twenty-nine participants were included in the analyses of the pre-test and 20 participants were included in the analyses of the post-test. A possible sample size loss can be attributed to the duration of the study. Participants have been asked to complete different tasks in a certain time frame. Further the study was conducted in the end of November and December. The end of the year is often experienced as a stressful period. It is therefore expected that participation rates would have been higher, if the study was conducted in the new year. As people try to stick to their New Year's resolutions, the game could have been an attractive medium to support people's resolutions. Nevertheless, the fact that the study was restricted to an Apple device would have kept the sample size possibly low anyway. Since Apple is one of the most expensive electronic brands it was in general challenging to reach out to participants with a recent Apple device. This makes it difficult to generalize results to the wider population of Dutch speaking adults. In particular, the results show only little power in terms of the small sample

size. Therefore, potential effects are not assessed and identified very well. Yet, potential effects may be a random result of chance.

## Suggestions for Further Research

The current study scientifically contributed to explore the effectiveness of serious games in health promotion. In terms of its societal relevance, this study showed that it is challenging to identify factors, which motivate individuals to play the game and potentially learn about nutrition. Therefore, the researcher of this study wants to encourage scientific research to further elucidate factors, which shape motivation to play serious health games. Thereby, effective and motivating serious games in health promotion can be designed.

In continuation of this study, further research should analyze the game data of King of FoodLand in detail. Thereby, it could be investigated in particular how individuals behave in the game. This can be compared to survey results, showing how individuals perceive their performance and motivation in comparison to their actual performance and motivation. For example, individual's self-determined motivation in comparison to individual's frequency and duration of playing can indicate their willingness to play. This will shape a broad picture of the effectiveness and its underlying mechanisms, applied to King of FoodLand and other serious games.

This study is a first quantitative study to test the effectiveness of King of FoodLand on knowledge gain about nutrition. Yet, it is interesting to further test whether the gained knowledge eventually changes people's behavior. Research has figured out that knowledge gain has a weak relationship with behavior. However, tailored information can serve as a moderator for the effects on behavioral determinants (DeSmet et al., 2014; Peng, 2009). Since King of FoodLand can be personalized to the player's age, gender, weight, sports, medical conditions and allergy it is interesting to measure the impacts of tailored information on individual's behavioral change of healthy eating. For example, research can be conducted whether particular level packs in King of Foodland, specifically targeting nutrition for individuals with e.g. kidney disease increase knowledge. Further, it can be tested whether those level packs affect actual game play and behavioral change. Thereby, it can be researched whether tailored information in serious games is a useful tool to strengthen knowledge gain, motivation and potentially even behavioral change.

With regard to measuring behavioral change effects, it is also important to perform studies on the long-term. By means of apps and games a large population of people could be reached. Thereby, a lot of information can be spread to a lot of people. However, it is not controllable how individuals interpret the information and how they act upon the information they receive (Bhargava & Tanghetti, 2016). By means of King of FoodLand it can be investigated how individuals understand and behave upon the information they receive. Thereby, it can be for example prevented that individuals who are at risk of eating disorders use the information of the game in a different way than it was initially

intended by game developers. By means of a mixed-method study, it can be researched how e.g. King of FoodLand is used among players and how it can be further controlled for possible 'misuse'. In addition, a literature study could provide information, how game and app developers deal with the challenge to spread information to many people, without knowing how information is adopted.

Also, the various functions of serious games should be tested in order to determine whether those contribute to knowledge effects. Since King of FoodLand will eventually include a Get Social button, it can be examined whether social connectedness in serious games motivates individuals to play the game. Moreover, research has stated that being physically active helps people maintaining knowledge, based on the idea that "*embodiment is an underpinning of cognition*" (Johnson-Glenberg & Hekler, 2013, p.354). Therefore, it can be researched whether levels that include a physical active part in the game stimulate knowledge maintenance. Another topic to research is serious games in intercultural settings. King of FoodLand is planned to be released in different countries and therefore represents different eating cultures and languages. It is interesting to research which factors contribute to the effectiveness of the game and how preferences of game functions differ in various countries and cultures. Also, research can be conducted to test in which settings the game can be promoted. For example, in cooperation with a health insurance the game can be implemented for people who need to lose weight. Thereby, it can be tested whether this game is effective and motivating for individuals who face the challenge of losing weight.

In terms of further research in nutrition education programs, it is highly important to conduct research whether serious games are more effective than conventional nutrition education. King of FoodLand can be researched in comparison to paper-written nutrition materials. Thereby, two groups can be compared with each other, one being exposed to the game and one being exposed to the conventional medium of paper-written nutrition materials. By means of implementing a control group, conclusions can be drawn whether effects can be attributed to the serious game. Within this research it can be further checked whether SES influences knowledge effects and motivation, as research reveals that people with a lower SES, who have generally less nutrition knowledge and often do not comply with dietary guidelines tend to be rather users of technology than of print media (McKinnon et al., 2014).

In conclusion, the current study showed significant improvements on nutrition knowledge during the intervention time. Yet, whether the results can be attributed to playing the serious game King of FoodLand cannot be stated in the current study. With a number of limitations and strengths such as the lack of a control group and the testing in a real world setting, the author of this study recommends to conduct further research on serious games in health promotion. In order to advance the research field of serious games in health promotion it still needs to be analyzed which motivational factors contribute to learning effects and how learning can be promoted in the most effective way. In fact, it needs to be researched whether the use of serious games is an effective enrichment in nutrition education.

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# Appendices

## Appendix I Participation Recruitment

**Deelnemers gezocht voor onderzoek Wageningen University naar informatie over voeding**

**Bent u in bezit van een Apple iPhone/iPad/iPod Touch (iOS 8 of hoger) en vind u het leuk om een nieuwe game (gratis!) te testen?** Dan komt u in aanmerking voor het volgende onderzoek:

Wageningen University voert momenteel een onderzoek uit naar een nieuwe game. Deze game geeft u spelenderwijs informatie over de voedingsstoffen in uw eten. We willen graag weten wat u van deze game vindt en of het u helpt om meer te weten te komen over voedingsmiddelen. Met uw deelname helpt u om de game te verbeteren.

Voor dit onderzoek zoeken wij 100 mannen en vrouwen die mee willen doen.

**Wat houdt meedoen in?**

- U registreert u voor het onderzoek via https://wur.az1.qualtrics.com/SE/?SID=SV_dgNX5J0f9NcKDsh
- Dan start het onderzoek met een korte vragenlijst die u via uw computer, tablet of telefoon kunt invullen vanaf 23 november (duur ongeveer 10 minuten).
- Na het invullen van de vragenlijst, ontvangt u via uw apple ID (het e-mail adres dat aan uw apple product gekoppeld is) toegang tot de game.
- Met de app TestFlight, die u op uw iPhone/iPad/iPod Touch download, kunt u de game downloaden.
- We vragen u om in de 2 weken na het invullen van de vragenlijst de game zo vaak te spelen als u wilt, maar minimaal één keer.
- Na twee weken ontvangt u opnieuw een e-mail met een link naar de laatste vragenlijst (duur ongeveer 20 minuten).

Het onderzoek wordt uitgevoerd tussen 23 november en 14 december 2015.

**U komt in aanmerking voor deelname aan dit onderzoek wanneer u:**

- 18 jaar of ouder bent.
- In bezit van een Apple iPhone/iPad/iPod Touch (iOS 8 of hoger) bent.
- Nederlands kunt lezen.

**Wat staat er voor u tegenover?**

- U ontvangt interessante informatie over voedingsstoffen en voedingsmiddelen.
- U ontvangt een gratis test versie van een nieuwe game (tot nu toe nog niet op de markt verkrijgbaar).
- Onder deelnemers die het onderzoek afronden, verloten we **6 iTunes cadeaubonnen ter waarde van 15€** als u de tweede vragenlijst ingevult heeft. Tip: Bij het delen van deze post (openbaar maken) maakt u verhoogd kans op één van de **iTunes cadeaubonnen**.
- U levert een belangrijke bijdrage aan wetenschappelijk onderzoek en het verbeteren van informatie over voeding.

**Interesse?**

Bent u geïnteresseerd in deelname aan het onderzoek? Open dan de volgende link https://wur.az1.qualtrics.com/SE/?SID=SV_dgNX5J0f9NcKDsh en registreer u nu. Dan ontvangt u op 23 november de eerste vragenlijst en toegang tot de game. **Like en share de link met uw vrienden!**

Heeft u nog vragen? U kunt via e-mail contact opnemen met de onderzoekers via ayla.schwarz@wur.nl

Alvast hartelijk dank voor uw medewerking!

Dr. Emely de Vet (hoofddocent Gezondheidscommunicatie) & Ayla Schwarz (MSc student Applied Communication Science).

## Appendix II Participation Qualification

I1 Registratie voor onderzoek Wageningen University naar informatie over voeding  Leuk dat u aan dit onderzoek mee wilt doen. Wilt u alstublief de volgende vragen invullen, om u voor het onderzoek te registreren? Alle antwoorden worden anoniem verwerkt. Uw gegevens worden uitsluitend voor het onderzoek gebruikt en worden niet aan derden verstrekt.

Q1 Bent u 18 of ouder?

- ❍ Ja (1)
- ❍ Nee (2)

Answer If Bent u ouder dan 18? Ja Is Selected

Q2 Kunt u Nederlands lezen?

- ❍ Ja (1)
- ❍ Nee (2)

Answer If Spreekt of verstaat u Nederlands? Ja Is Selected

Q3 Bent u in bezit van een iPhone/iPad/iPod Touch met iOS 8 of hoger?

- ❍ Ja (1)
- ❍ Nee (2)

Answer If Bent u in het bezit van een iPhone/iPad/iPod Touch met iOS 8 of hoger? Ja Is Selected

Q4 Wat is uw Apple-ID? Dus het e-mail adres dat aan uw apple iPhone/iPad/iPod Touch gekoppeld is.

- ❑ Mijn Apple-ID is: (1) _____
- ❑ Apple-ID bevestigen (2) _____

Answer If Wat is uw Apple-ID? Dus het e-mail adres dat aan uw apple iPhone/iPad/iPod Touch gekoppeld is. Mijn Apple-ID is: Is Selected

Q8 Op welk e-mail adres wilt u de vragenlijsten ontvangen?

- ❍ Hetzelfde e-mail adres als mijn Apple-ID (1)
- ❍ Anders, namelijk: (2) _____

If Hetzelfde e-mail adres als ... Is Selected, Then Skip To Bedankt voor de registratie! Zodra he...If Anders, namelijk: Is Selected, Then Skip To Bedankt voor de registratie! Zodra he...

Answer If Bent u ouder dan 18? Nee Is Selected Or Spreekt of verstaat u Nederlands? Nee Is Selected Or Bent u in het bezit van een iPhone/iPad/iPod Touch met iOS 8 of hoger? Nee Is Selected

Q7 Helaas, u komt niet in aanmerking voor dit onderzoek. Bedankt voor uw interesse!

If Helaas, u komt niet in aanm... Is Displayed, Then Skip To End of Survey

I2 Bedankt voor de registratie! Zodra het onderzoek van start gaat op 23 november krijgt u de eerste vragenlijst naar uw e-mail adres toegestuurd. Wilt u dit alstublief voor het system nog bevestigen? Klik verder!

## Appendix III Level Blocks

In detail, the first level block about **energy** included five levels where participants had to indicate:

1. Which food products do not contain calories
2. Which food products contain a lot or few calories
3. Which food products contain most or least calories
4. How many calories food products contain per portion
5. Which activities burn how many calories

The second level block about **macronutrients** included five levels about:

1. Food products which contain fat
2. Food products which contain carbohydrates
3. Food products which contain proteins
4. The percentage of alcohol
5. Higher or lower in fat, carbohydrates or proteins

The third level block about **vitamins** included five levels about:

1. The differences of vitamin A, vitamin C, vitamin D
2. Food products which only contain vitamin C
3. Food products which only contain vitamin A
4. Food products which only contain vitamin D
5. More or less vitamin A, vitamin C, vitamin D per 100 gram

## Appendix IV Pre-test

I Hartelijk dank voor uw deelname aan het onderzoek naar informatie over voeding (Wageningen University). We vragen u nu deze vragenlijst in te vullen. Het invullen duurt ongeveer 10 minuten. Uw gegevens worden uitsluitend voor het onderzoek gebruikt en worden niet aan derden verstrekt. Zodra u de vragenlijst ingevuld heeft, krijgt u toegang tot de game.

I De volgende vragen gaan over voeding. Kruis alstublieft het juiste antwoord aan.

Q1 Het zetmeel in een boterham is een _____.
- Vet (1)
- Vitamine (2)
- Koolhydraat (3)
- Eiwit (4)

Q2 Voedingsmiddelen zoals olie of boter zijn rijk aan _____.
- Vitamine C (1)
- Koolhydraten (2)
- Ijzer (3)
- Vet (4)

Q3 De/het _____ in sinaasappelsap is een koolhydraat.
- Suiker (1)
- Calcium (2)
- Eiwit (3)
- Foliumzuur (4)

Q4 Voedingsmiddelen zoals eieren, kip en vis zijn een goede bron van _____.
- Zetmeel (1)
- Eiwit (2)
- Vezel (3)
- Suiker (4)

Q5 Boter, reuzel en cheddar kaas bieden grote hoeveelheden _____ vet.
- Meervoudig onverzadigd (1)
- Verzadigd (2)
- Enkelvoudig onverzadigd (3)
- Trans (4)

Q6 Omdat het een goede bron van _____ is, zouden vegetariërs bruine bonen kunnen eten.
- Vitamine D (1)
- Vitamine B-12 (2)
- Vet (3)
- Eiwit (4)

I2 Het onderstaande voedseletiket is van een kant en klaar maaltijd macaroni ham kaas. Hieronder staan een aantal vragen over het etiket.

I3

**Uitgebreide productinformatie**

**Voedingswaarden**

| | %* | per 100 g: | per 450 g: |
|---|---|---|---|
| Energie | 29% | kJ 537 / kcal 128 | kJ 2417 / kcal 575 |
| Vetten | 28% | 4.3 g | 19.4 g |
| Waarvan Verzadigde Vetzuren | 54% | 2.4 g | 10.8 g |
| Koolhydraten | | 16.0 g | 72.0 g |
| Waarvan Suikers | 8% | 1.6 g | 7.0 g |
| Vezels | | 0.5 g | 2.3 g |
| Eiwitten | | 6.0 g | 27.0 g |
| Zout | 49% | 0.7 g | 2.9 g |

* Referentie-inname Van Een Gemiddelde Volwassene (8.400 KJ/2.000 Kcal).

Deze Verpakking Bevat 1 Portie.

I4

**Dagelijkse Voedingsrichtlijn (GDA)**

Van de aanbevolen dagelijkse hoeveelheid (volwassenen) bevat iedere portie:

Per Portion

een maaltijd (450 g) bevat


van de dagelijkse referentie-inname*

per 100 g: 128 kcal.

* Referentie-inname van een gemiddelde volwassene (8.400 kJ/2.000 kcal).

van de aanbevolen dagelijkse hoeveelheid voor volwassenen

Q7 Hoeveel calorieën zou u eten als u de hele inhoud van de kant en klaar maaltijd zou eten?

- 128 kcal (1)
- 575 kcal (2)
- 700 kcal (3)
- 757 kcal (4)

Q8 Als u probeert om minder dan 10 gram suikers per maaltijd te eten, hoeveel porties macaroni ham kaas kunt u dan eten, als u niets anders eet?

- 1 portie (1)
- 2 porties (2)
- 3 porties (3)
- 4 porties (4)

Q9 Hoeveel gram koolhydraten zou u met 2 porties macaroni ham kaas eten?
- ❍ 16 gram (1)
- ❍ 32 gram (2)
- ❍ 72 gram (3)
- ❍ 144 gram (4)

Q10 Welk van de volgende nutriënten staan niet op dit voedseletiket?
- ❍ Totale vetgehalte (1)
- ❍ Natrium (2)
- ❍ Vezels (3)
- ❍ Suiker (4)

Q11 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevat spaghetti meer calorieën dan een muesli reep. (1) | ❍ | ❍ |
| Per 100 gram bevatten gezouten pinda's meer calorieën dan salami. (2) | ❍ | ❍ |
| Per portie bevat een gezouten haring (75g) meer calorieën dan een rauw ei (50 g). (3) | ❍ | ❍ |
| Per 100 gram bevat Gouda 48+ kaas meer calorieën dan een croissant. (4) | ❍ | ❍ |

Q12 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevatten kippenboutjes ten opzichte van aardbeien meer koolhydraten. (1) | ❍ | ❍ |
| Per 100 gram bevat een banaan meer koolhydraten dan cornflakes. (2) | ❍ | ❍ |
| Per 100 gram bevat cola minder vet dan een gezouten haring. (3) | ❍ | ❍ |
| Per 100 gram bevat vers geperste sinaasappelsap meer koolhydraten dan een rauwe varkensvlees schnitzel. (4) | ❍ | ❍ |

Q13 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevat rauw spek meer vitamine A dan gezouten haring. (1) | ❍ | ❍ |
| Per 100 gram bevat rauwe selderij meer vitamine A dan rauwe bloemkool. (2) | ❍ | ❍ |
| Per 100 gram bevatten gezouten pinda's meer vitamine D dan Gouda 20+ kaas. (3) | ❍ | ❍ |
| Per 100 gram bevat een croissant minder vitamine A dan een citroen. (4) | ❍ | ❍ |

Q14 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Vloeibare vormen van bakvet (zoals olie, vloeibaar bak- en braadvet) zijn gezonder dan harde vormen (pakje bakvet). (1) | ❍ | ❍ |
| Als je zelf geen zout aan het eten toevoegt, dan krijg je weinig zout binnen. (2) | ❍ | ❍ |

I5 Tot slot willen we u nog een paar algemene vragen stellen.
Q15 Mijn apple ID is:
❍ Uw apple ID wordt alleen voor dit onderzoek gebruikt. Na afloop van dit onderzoek wordt uw apple ID in ons systeem gewist. (1) _____

Q16 Wat is u geboortedatum?
❍ dd/mm/jjjj (1) _____

Q17 Wat is uw geslacht?
❍ Man (1)
❍ Vrouw (2)

Q18 In welk land bent u geboren?
❍ Nederland (1)
❍ Turkije (2)
❍ Marokko (3)
❍ Suriname (4)
❍ Nederlandse Antillen (5)
❍ Anders, namelijk (6) _____

Q19 In welk land is uw moeder geboren?
❍ Nederland (1)
❍ Turkije (2)
❍ Marokko (3)
❍ Suriname (4)
❍ Nederlandse Antillen (5)
❍ Anders, namelijk (6) _____

Q20 In welk land is uw vader geboren?
❍ Nederland (1)
❍ Turkije (2)
❍ Marokko (3)
❍ Suriname (4)
❍ Nederlandse Antillen (5)
❍ Anders, namelijk (6) _____

Q21 Wat is de hoogste opleiding die u afgerond heeft?
❍ Basis school (1)
❍ Lbo (lager beroepsonderwijs) (2)
❍ Mavo (middelbaar algemeen voortgezet onderwijs) (3)
❍ Vmbo (voorbereidend middelbaar beroepsonderwijs) (4)
❍ Mbo-1 (middelbaar beroepsonderwijs –assistentenopleiding) (5)

- Mbo-2-4 (middelbaar beroepsonderwijs –basisberoepsopleiding, vakopleiding, specialisatieopleiding) (6)
- Havo (hoger algemeen voortgezet onderwijs) (7)
- Vwo (voorbereidend wetenschappelijk onderwijs) (8)
- Hbo (hoger beroepsonderwijs) (9)
- Wo (wetenschappelijk onderwijs) (10)

Q22 Heeft u een achtergrond in voeding? (bijv. professie of opleiding)
- Ja (1)
- Nee (2)

Q23 Doet u zelf de boodschappen?
- Ja (1)
- Nee (2)

Q24 Volgt u bepaalde leefregels wat betreft uw voeding?
- Ja, vegetarisch (1)
- Ja, veganistisch (2)
- Ja, macrobiotische (3)
- Ja, antroposofisch (4)
- Ja, religieus (5)
- Ja, religieus (6)
- Ja, anders namelijk (7) _____
- Nee (8)

Q25 Volgt u op het moment een dieet?
- Ja, om af te vallen (1)
- Ja, vanwege suikerziekte (diabetes) (2)
- Ja, vanwege een te hoog cholesterol (3)
- Ja, vanwege een te hoge bloeddruk (4)
- Ja, nameijk om (5) _____
- Nee (6)

Answer If Volgt u op het moment een dieet? Ja, om af te vallen Is Selected Or Volgt u op het moment een dieet? Ja, vanwege suikerziekte (diabetes) Is Selected Or Volgt u op het moment een dieet? Ja, vanwege een te hoog cholesterol Is Selected Or Volgt u op het moment een dieet? Ja, vanwege een te hoge bloeddruk Is Selected Or Volgt u op het moment een dieet? Ja, nameijk om Is Selected

Q26 Welk dieet volgt u op het moment?
- Atkins (1)
- Bloedgroepdieet (2)
- Broodwisseldieet (3)
- Carr-methode (4)
- Detox-dieet (5)
- Dr. Frank-dieet (6)
- GI-dieet (7)
- Hormoonbalansdieet (8)
- Immogenics (9)
- Leven Lang fit (10)
- Montignac (11)
- Orthomoleculair (12)

- Paleo (13)
- Raw food (14)
- Sapkuren (15)
- Sonja Bakker (16)
- South Beach (17)
- Voedselzandloper (18)

End Doel van het onderzoek  Wageningen University voert momenteel een onderzoek uit naar een nieuwe game. Deze game geeft u spelenderwijs informatie over de voedingsstoffen in uw eten. We willen graag weten wat u van deze game vindt en of het u helpt om meer te weten te komen over voedingsmiddelen. Met uw deelname helpt u om de game te verbeteren.  Wat houdt meedoen in?  Het onderzoek met een korte vragenlijst die u via uw computer, tablet of telefoon kunt invullen vanaf 23 november (duurt ongeveer 10 minuten).  Na het invullen van de vragenlijst, ontvangt u via uw apple ID (het e-mail adres dat aan uw apple product gekoppeld is) toegang tot de game.  Met de app TestFlight, die u op uw iPhone/iPad/iPod Touch download, kunt u de game downloaden.  We vragen u om in de 2 weken na het invullen van de vragenlijst de game zo vaak te spelen als u wilt, maar minimaal één keer.  Na twee weken ontvangt u opnieuw een e-mail met een link naar de laatste vragenlijst (duur ongeveer 20 minuten).  Het onderzoek wordt uitgevoerd tussen 23 november en 14 december 2015.  U komt in aanmerking voor deelname aan dit onderzoek wanneer u:  18 jaar of ouder bent.  In bezit van een Apple iPhone/iPad/iPod Touch (iOS 8 of hoger) bent.  Nederlands kunt lezen.  Wat staat er voor u tegenover?  U ontvangt interessante informatie over voedingsstoffen en voedingsmiddelen.  U ontvangt een gratis test versie van een nieuwe game (tot nu toe nog niet op de markt verkrijgbaar).  Onder deelnemers die het onderzoek afronden, verloten we 6 iTunes cadeaubonnen ter waarde van 15€ als u de tweede vragenlijst ingevult heeft. Tip: Bij het delen van deze post (openbaar maken) maakt u verhoogd kans op één van de iTunes cadeaubonnen.  U levert een belangrijke bijdrage aan wetenschappelijk onderzoek en het verbeteren van informatie over voeding.

- VERKLARING: Ik verklaar dat ik op de hoogte ben van het doel van het onderzoek en geef hierbij toestemming voor het gebruik van mijn gegevens. Gegevens worden uitsluitend voor het onderzoek gebruikt en worden niet aan derden verstrekt. Klik op de text om je verklaring te bevestigen. (1)

## Appendix V Post-test

I Hartelijk dank voor uw deelname aan het onderzoek naar games en informatie over voeding van Wageningen University. We vragen u nu de laatste vragenlijst in te vullen. Het invullen duurt ongeveer 20 minuten. Uw gegevens worden uitsluitend voor het onderzoek gebruikt en worden niet aan derden verstrekt.

Check Kunt u alstublieft nog een keer uw apple ID (dus het e-mail adres dat met uw apple product gekoppeld is) aangeven?

Check Mijn apple ID is:

- ❑ bijv. a.voorbeeld@hotmail.nl (1) _____

Check Wat is uw geboortedatum?

- ❍ dd/mm/yyyy (1) _____

Q1 Hoeveel level blocks heeft het spel tot nu toe?

- ❍ 2, namelijke over 1) energie en 2) vitaminen (1)
- ❍ 3, namelijk over 1) energie, 2) nutriënten en 3) vitaminen (2)
- ❍ 1, namelijk over 1) mineralen (3)

Q2 Welk kleurenkader heeft het spel?

- ❍ Gekleurd (1)
- ❍ Zwart-wit (2)

I1 De volgende vragen gaan over voeding. Kruis alstublieft het juiste antwoord aan.

Q3 Het zetmeel in een boterham is een _____.

- ❍ Vet (1)
- ❍ Vitamine (2)
- ❍ Koolhydraat (3)
- ❍ Eiwit (4)

Q4 Voedingsmiddelen zoals olie of boter zijn rijk aan _____.

- ❍ Vitamine C (1)
- ❍ Koolhydraten (2)
- ❍ Ijzer (3)
- ❍ Vet (4)

Q5 De/het _____ in sinaasappelsap is een koolhydraat.

- ❍ Suiker (1)
- ❍ Calcium (2)
- ❍ Eiwit (3)
- ❍ Foliumzuur (4)

Q6 Voedingsmiddelen zoals eieren, kip en vis zijn een goede bron van _____.

- ❍ Zetmeel (1)
- ❍ Eiwit (2)
- ❍ Vezel (3)
- ❍ Suiker (4)

Q7 Boter, reuzel en cheddar kaas bieden grote hoeveelheden _____ vet.

- ❍ Meervoudig onverzadigd (1)
- ❍ Verzadigd (2)

- Enkelvoudig onverzadigd (3)
- Trans (4)

Q8 Omdat het een goede bron van _____ is, zouden vegetariërs bruine bonen kunnen eten.

- Vitamine D (1)
- Vitamine B-12 (2)
- Vet (3)
- Eiwit (4)

I2 Het onderstaande voedseletiket is van een kant en klaar maaltijd Macaroni Ham Kaas. Hieronder staan een aantal vragen over het etiket.

I3

**Uitgebreide productinformatie**

**Voedingswaarden**

| | %* | per 100 g: | per 450 g: |
|---|---|---|---|
| Energie | 29% | kJ 537 / kcal 128 | kJ 2417 / kcal 575 |
| Vetten | 28% | 4.3 g | 19.4 g |
| Waarvan Verzadigde Vetzuren | 54% | 2.4 g | 10.8 g |
| Koolhydraten | | 16.0 g | 72.0 g |
| Waarvan Suikers | 8% | 1.6 g | 7.0 g |
| Vezels | | 0.5 g | 2.3 g |
| Eiwitten | | 6.0 g | 27.0 g |
| Zout | 49% | 0.7 g | 2.9 g |
| * Referentie-inname Van Een Gemiddelde Volwassene (8.400 KJ/2.000 Kcal). | | | |
| Deze Verpakking Bevat 1 Portie. | | | |

I4

**Dagelijkse Voedingsrichtlijn (GDA)**

Van de aanbevolen dagelijkse hoeveelheid (volwassenen) bevat iedere portie:

Per Portion

een maaltijd (450 g) bevat


van de dagelijkse referentie-inname*

per 100 g: 128 kcal.

* Referentie-inname van een gemiddelde volwassene (8.400 kJ/2.000 kcal).

van de aanbevolen dagelijkse hoeveelheid voor volwassenen

Q9 Hoeveel calorieën zou u eten als u de hele inhoud van de kant en klaar maaltijd zou eten?
- ❍ 128 kcal (1)
- ❍ 575 kcal (2)
- ❍ 700 kcal (3)
- ❍ 757 kcal (4)

Q10 Als u probeert om minder dan 10 gram suikers per maaltijd te eten, hoeveel porties macaroni ham kaas kunt u dan eten, als u niets anders eet?
- ❍ 1 portie (1)
- ❍ 2 porties (2)
- ❍ 3 porties (3)
- ❍ 4 porties (4)

Q11 Hoeveel gram koolhydraten zou u met 2 porties macaroni ham kaas eten?
- ❍ 16 gram (1)
- ❍ 32 gram (2)
- ❍ 72 gram (3)
- ❍ 144 gram (4)

Q12 Welk van de volgende nutriënten staan niet op dit voedseletiket?
- ❍ Totale vetgehalte (1)
- ❍ Natrium (2)
- ❍ Vezels (3)
- ❍ Suiker (4)

Q13 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevat spaghetti meer calorieën dan een muesli reep. (1) | ❍ | ❍ |
| Per 100 gram bevatten gezouten pinda's meer calorieën dan salami. (2) | ❍ | ❍ |
| Per portie bevat een gezouten haring (75g) meer calorieën dan een rauw ei (50 g). (3) | ❍ | ❍ |
| Per 100 gram bevat Gouda 48+ kaas meer calorieën dan een croissant. (4) | ❍ | ❍ |

Q14 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevatten kippenboutjes ten opzichte van aardbeien meer koolhydraten. (1) | ❍ | ❍ |
| Per 100 gram bevat een banaan meer koolhydraten dan cornflakes. (2) | ❍ | ❍ |
| Per 100 gram bevat cola minder vet dan een gezouten haring. (3) | ❍ | ❍ |
| Per 100 gram bevat vers geperste sinaasappelsap meer koolhydraten dan een rauwe varkensvlees schnitzel. (4) | ❍ | ❍ |

Q15 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Per 100 gram bevat rauw spek meer vitamine A dan gezouten haring. (1) | ❍ | ❍ |
| Per 100 gram bevat rauwe selderij meer vitamine A dan rauwe bloemkool. (2) | ❍ | ❍ |
| Per 100 gram bevatten gezouten pinda's meer vitamine D dan Gouda 20+ kaas. (3) | ❍ | ❍ |
| Per 100 gram bevat een croissant minder vitamine A dan een citroen. (4) | ❍ | ❍ |

Q16 Zijn de volgende stellingen waar of niet waar?

| | Waar (1) | Niet waar (2) |
|---|---|---|
| Vloeibare vormen van bakvet (zoals olie, vloeibaar bak- en braadvet) zijn gezonder dan harde vormen (pakje bakvet). (1) | ❍ | ❍ |
| Als je zelf geen zout aan het eten toevoegt, dan krijg je weinig zout binnen. (2) | ❍ | ❍ |

I5 Wij zijn benieuwd naar uw mening over de informatie in het spel. Het gaat dan om uw beoordeling van alle informatie in het spel en omvat de introducties, de uitleg, de vragen en de bijhorende antwoorden over de voedingsproducten in het spel. Kruis alstublieft aan in hoeverre u het eens of oneens bent met de volgende stellingen.

Q17 De informatie in het spel...

| | Helemaal mee oneens (1) | Mee oneens (2) | Niet mee eens/ niet mee oneens (3) | Mee eens (4) | Helemaal mee eens (5) |
|---|---|---|---|---|---|
| is duidelijk geformuleerd. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| is overzichtelijk gepresenteerd. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| is zo duidelijk beschreven dat ik het mij kan herinneren. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |
| is boeiend. (4) | ❍ | ❍ | ❍ | ❍ | ❍ |
| heeft mij aan het denken gezet. (5) | ❍ | ❍ | ❍ | ❍ | ❍ |
| gaat over een onderwerp, waar ik al veel vanaf wist. (6) | ❍ | ❍ | ❍ | ❍ | ❍ |
| kende ik al. (7) | ❍ | ❍ | ❍ | ❍ | ❍ |
| is compleet. (8) | ❍ | ❍ | ❍ | ❍ | ❍ |
| is logisch. (9) | ❍ | ❍ | ❍ | ❍ | ❍ |
| heeft mijn aandacht gegrepen. (10) | ❍ | ❍ | ❍ | ❍ | ❍ |

Q18 En hoe denk u over de volgende stellingen?

| | Helemaal mee oneens (1) | Mee oneens (2) | Niet mee eens/ niet mee og eens/oneens (3) | Mee eens (4) | Helemaal mee eens (5) |
|---|---|---|---|---|---|
| De levels gaan soepel in elkaar over. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| In de laatste twee weken heb ik zelf informatie over voeding gezocht. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| In de laatste twee weken heb ik van mensen om mij heen informatie over voeding gekregen. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |

Q19 Hoe denkt u over de volgende stellingen? Geef aan in hoeverre u het oneens of eens bent met de volgende stellingen.

| | Nooit waar (1) | Bijna nooit waar (2) | Meestal niet waar (3) | Af en toe waar (4) | Meestal waar (5) | Bijna altijd waar (6) | Altijd waar (7) |
|---|---|---|---|---|---|---|---|
| Ik speelde het spel omdat ik geen andere keuze had. (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik verloor de aandacht tijdens het spelen. (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik begreep het spel vrij goed. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik zou het spel als zeer interessant omschrijven. (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik heb het spel gespeeld omdat ik het wilde. (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik vond het spelen vermakelijk. (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik had het gevoel dat ik het spel moest spelen. (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik vond het spel leuk om te spelen. (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik voelde mij voedingsdeskundig na een tijdje oefenen met het spel. (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik was tevreden met mijn prestatie in het spel. (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Q20 En ten slotte, hoe denkt u over de volgende stellingen? Geef u mening aan.

| | Helemaal mee oneens (1) | Mee oneens (2) | Een beetje mee oneens (3) | Niet mee oneens/ niet mee eens (4) | Een beetje mee eens (5) | Mee eens (6) | Helemaal mee eens (7) |
|---|---|---|---|---|---|---|---|
| De optie 'tips' hielp mij de uitdagingen in het spel aan te gaan. (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik ging op in het spel. (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik had controle over het spel. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik voelde mij betrokken in het spel. (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik wist wat ik kon verwachten bij de volgende stap in het spel. (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Tijdens het spelen had ik weinig besef van de tijd. (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Het spel bood mij nieuwe uitdagingen met een geschikte snelheid. (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Tijdens het spelen vergat ik wat er om mij heen gebeurde. (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Ik heb het gevoel dat het spel moeilijker werd naarmate het spel vordert. (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Tijdens het spelen vergat ik eventjes dagelijkse zorgen. (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Q21 Heeft u nog opmerkingen die u over dit onderzoek kwijt wilt?

- ❍ Ja, namelijk: (1) _____
- ❍ Nee (2)

Q22 Wilt u nog iets over het spel kwijt?

- ❍ Ja, namelijk: (1) _____
- ❍ Nee (4)

Q23 Wilt u op de hoogte gehouden worden van de resultaten van het onderzoek?

- ❍ Ja (1)
- ❍ Nee (2)

## Appendix VI Descriptive Statistics of Secondary Outcomes Measures

| | M | SD | SE | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **Situational Interest** | | | | | | |
| *Coherence* | | | | | | |
| Is duidelijke geformuleerd | 3.85 | 0.59 | 0.12 | 0.35 | 2 | 5 |
| Is overzichtelijk gepresenteerd | 3.95 | 0.39 | 0.09 | 0.16 | 3 | 5 |
| De levels gaan soepel in elkaar over | 3.15 | 1.04 | 0.23 | 1,08 | 1 | 4 |
| *Vividness* | | | | | | |
| Is zo duidelijk beschreven dat ik het mij kan herinneren | 3.00 | 0.91 | 0.22 | 0.95 | 1 | 5 |
| Is boeiend | 3.75 | 0.91 | 0.20 | 0.83 | 2 | 5 |
| *Information Completness* | | | | | | |
| Is compleet | 2.90 | 0.85 | 0.19 | 0.73 | 2 | 4 |
| Is logisch | 3.70 | 0.66 | 0.15 | 0.43 | 2 | 5 |
| *Suspense* | | | | | | |
| Heeft mijn aandacht gegrepen | 3.50 | 0.89 | 0.20 | 0.79 | 2 | 5 |
| *Confounding Variables* | | | | | | |
| In de laatste twee weken heb ik zelf informatie over voeding gezocht | 2.25 | 1.07 | 0.24 | 1.15 | 1 | 4 |
| In de laatste twee weken heb ik van mensen om mij heen informatie over voeding gekregen | 2.15 | 1.04 | 0.23 | 1.08 | 1 | 4 |
| | | | | | | |
| **Self-determined motivation** | | | | | | |
| *Perceived Choice* | | | | | | |
| Ik speelde het spel omdat ik geen andere keuze had (R) | 6.00 | 0.86 | 0.19 | 0.74 | 5 | 7 |
| Ik heb het spel gespeeld omdat ik het wilde | 5.60 | 1.00 | 0.22 | 0.99 | 4 | 7 |
| *Interest* | | | | | | |
| Ik verloor de aandacht tijdens het spelen (R) | 5.50 | 1.15 | 0.26 | 1.32 | 3 | 7 |
| Ik zou het spel als zeer interessant omschrijven | 5.20 | 1.28 | 0.29 | 1.64 | 3 | 7 |
| Ik vond het spelen vermakelijk | 5.05 | 0.83 | 0.19 | 0.68 | 4 | 7 |
| Ik vond het spel leuk om te spelen | 5.35 | 1.18 | 0.26 | 1.40 | 3 | 7 |
| *Perceived Competence* | | | | | | |
| Ik begreep het spel vrij goed | 5.70 | 0.92 | 0.21 | 0.85 | 4 | 7 |
| Ik was tevreden met mijn prestatie in het spel | 4.90 | 1.29 | 0.29 | 1.67 | 2 | 7 |

| Game Flow | M | SD | SE | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| *Challenge* | | | | | | |
| Het spel bood mij nieuwe uitdagingen met een geschikte snelhed | 3.95 | 1.70 | 0.38 | 2.89 | 1 | 7 |
| Ik heb het gevoel dat het spel moeilijker werd naarmate het spel vordert | 4.60 | 1.57 | 0.35 | 2.46 | 1 | 7 |
| *Immersion* | | | | | | |
| Ik ging op in het spel | 3.80 | 1.47 | 0.33 | 2.17 | 1 | 6 |
| Ik voelde mij betrokken in het spel | 4.85 | 1.14 | 0.25 | 1.29 | 3 | 7 |
| Tijdens het spelen had ik weinig besef van de tijd | 3.65 | 1.69 | 0.38 | 2.87 | 1 | 7 |
| Tijdens het spelen vergat ik wat er om mij heen gebeurde | 3.25 | 1.80 | 0.40 | 3.25 | 1 | 7 |
| Tijdens het spelen vergat ik eventjes dagelijkse zorgen | 3.35 | 1.87 | 0.42 | 3.50 | 1 | 7 |
| *Autonomy* | | | | | | |
| Ik had controle over het spel | 4.55 | 1.43 | 0.32 | 2.05 | 2 | 6 |
| Ik wist wat ik kon verwachten bij de volgende stap in het spel. | 4.30 | 1.53 | 0.34 | 2.33 | 1 | 6 |

Note: N=20