MASTER'S THESIS

Implementing a new instructional design framework in an animated pedagogical agent:

Does an animated pedagogical agent enhance student motivation and learning gains?

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Abstract

This study investigated whether an animated pedagogical agent (APA) affected student motivation and learning in a simulation on a science topic. The APA focused on students' perceptions of task-relevance and self-efficacy beliefs. For the construction of the APA a motivational design model was newly developed. This model combined expectancy-value theory (Eccles & Wigfield, 2002), self-efficacy theory (Bandura, 1977) and the ARCS Model (Keller, 1987;2010).

In an experiment with 68 high school students, an APA condition was compared with a no-APA control condition. Gender was evenly distributed over conditions. For initial motivation, a gender difference was found with girls scoring lower than boys. After completing two-thirds of the training, students in the control condition gave significantly higher appraisals for self-efficacy than students in the APA condition. In addition, girls expressed higher perceptions of task-relevance than boys effect of gender on task and condition. After training, an interaction effect showed that the self-efficacy of girls had increased most in the APA condition while self-efficacy of boys increased most in the control condition. For task-relevance a main effect of condition was found, in favor of the control condition. For knowledge gains there were main effects for condition and gender. The control condition yielded more learning gains than the APA condition, and girls learned more than boys. The discussion explains the outcomes with reference to gender differences in initial motivation, the possibility of gender-sensitive motivational strategies and the gender-specific visual presentation of the APA (i.e., a girl). In addition, the question is raised how to draw students' attention to their perceptions of task-relevance and self-efficacy beliefs during training without disturbing their learning focus.

Keywords: animated pedagogical agent, self-efficacy, task-relevance, learning

INTRODUCTION

This study investigates the use of a pedagogical agent as a motivational scaffold in a simulation. The simulation used in this study is the *Motion* learning environment created with *SimQuest* (de Jong, van Joolingen, Veermans & van der Meij, 2005), which covers the physics domain of kinematics. Most simulations, including the *SimQuest* learning environment, are used for learning to understand conceptual models, by inferring the characteristics of these models through experimentation. This experimental investigation is known as (simulation-based) inquiry learning. In an inquiry learning environment, students actively undertake different cognitive activities to develop new knowledge and skills and discover the domain characteristics (Veermans, Van Joolingen & De Jong, 2006), as well as metacognitive activities such as planning and reflection (Edelson, Gordin & Pea, 1999). Because of its active character, students engaged in inquiry learning learn more deeply (Mayer, 2003).

Inquiry learning without scaffolding is, however, not beneficial for learning (e.g. De Jong & Van Joolingen, 1998), or even found to be ineffective (Mayer, 2004). Without guidance, inquiry learning is too open to students, and can therefore be overwhelming and frustrating, which decreases student motivation and learning gains. This supports that not only cognitive and metacognitive support, which have been very well-researched and measured (e.g. Kalyuga, Ayres, Chandler & Sweller, 2003; Zimmerman 2008), but also motivational support is needed. Although motivation has shown to be of (great) importance and "significantly influences learning resources" (Astleitner & Wiesner, 2004), not much research has been done on motivational support for inquiry learning.

This study investigates the possibilities for scaffolding student motivation in a simulation, focusing especially on girls learning physics. Female students often have low self-efficacy levels (self-efficacy beliefs are an individual's beliefs about his/her abilities to accomplish a task (Pintrich & Schunk, 2002; Bandura, 1977)) when it comes to learning science or mathematics (e.g. Arroyo, Woolf, Cooper, Burleson & Muldner, 2011; Ceci, Williams & Barnett, 2009; Eccles, Wigfield, Harold & Blumenfeld, 1993) and utility of these subjects (i.e. "student's belief that mathematics is valuable to learn" (Eccles et al., 1993; Catsambis, 2005, as mentioned in Arroyo et al., 2011)). This is implied by sociocultural causes, rather than biological causes (Ceci, Williams & Barnett, 2009), because these subjects are accepted as being masculine and girls feel like they should fit their (gender) identity with corresponding gender stereotypes (Nosek, Banaji, & Greenwald, 2002; Kerger, Martin & Brunner, 2011).

Research by Van der Meij, Van der Meij and Harmsen (submitted) shows that integrating a female animated pedagogical agent (APA, in this article henceforth referred to as agent) named Emma to the learning environment increases learning gains and student motivation. Pedagogical agents are lifelike characters presented on a computer screen that guide users through multimedia learning environments." (Heidig & Clarebout, 2011, pp. 28). The current study focuses on Van der Meij et al.'s (submitted) study, as well as on original theoretical psychological literature on student motivation. Although Van der Meij et al.'s (submitted) study showed very promising results on the effects of a motivational agent on students' learning gains and student motivation, especially on reducing the gender differences for self-efficacy (which initially was lower for girls), there are possibilities for improvement. For example, despite their progress, girls still showed lower self-efficacy belief scores than boys after training. This study was limited due to its exploratory character. Van der Meij et al. (submitted) focused their narrative on Keller's (1987; 2010) ARCS Model, which provides many practical strategies for motivational design. Although it is confined to base a design on one single model, this research forms a solid foundation to build from. Keller (1987; 2010) focused his motivational design model on the student in a learning context, for example in a classroom setting and within a curriculum.

The current study combines the ARCS Model (Keller, 1987; 2010) with expectancy-value theory (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983; Eccles & Wigfield, 2002; Eccles et al., 1993; Wigfield & Eccles, 1992, 2000), and self-efficacy theory (Bandura, 1977), constructing a new theory of instructional motivation that can be integrated in the design of the agent, focusing on agent Emma's motivational comments. More details about the other aspects of the design of the agent used in this study (e.g. visual presence, animation level) can be found in Van der Meij et al.'s (submitted) article.

1. Motivational Theory

"Motivation is the process whereby goal-directed activity is instigated and sustained" (Pintrich & Schunk, 1996, pp. 5). This goal-directed activity indicates that "students motivated to learn about a topic are apt to engage in activities they believe will help them learn, such as attend carefully to the instruction, mentally organize and rehearse the material to be learned, take notes to facilitate subsequent studying, check their level of understanding, and ask for help when they do not understand the material (Zimmerman & Martinez-Pons, 1992). Collectively, these activities improve learning." (Pintrich & Shunk, 2002, pp. 6). Therefore, it is very important that student motivation is activated and sustained throughout training. The question is how motivation can be activated.

Expectancy-Value Theory

The main motivational theory that the current study focuses on is Expectancy-Value Theory (Eccles et al., 1983; Eccles & Wigfield, 2002; Eccles et al., 1993; Wigfield & Eccles, 1992, 2002), which is a model of (achievement) motivation. Eccles et al. (1983) stated that student motivation (including achievement performance, persistence and choice of achievement tasks) is most directly predicted by students' expectancies for success on a learning task and the (subjective) value that students attach to success on this task. Students will be more motivated when they expect to succeed on a learning task that they have attached value to. Therefore, the motivational support in the current study focuses on these two aspects of motivation: expectancy (for success) and value (of the learning task).

A. Expectancy

Students' expectancies for success are highly based on their self-efficacy beliefs, which are an individual's beliefs about his/her abilities to accomplish a task (Pintrich & Schunk, 2002; Bandura, 1977). This belief results in an individual's "outcome expectations", which are beliefs that a certain behavior will lead to a certain outcome, and "efficacy expectations", which are beliefs that an individual can effectively perform the behaviors that are necessary to produce the desired outcome (Bandura, 1977). The core question for self-efficacy belief (also referred to simply as self-efficacy) is: "Can I do this task?" (Pintrich & Schunk, 2002, pp. 53). When an individual's expectations are not positive (or: if the answer to this core question isn't positive), and thus is expecting to fail, it will be less likely that this person will engage in the learning task (Pintrich & Schunk, 2002, pp. 52; Atkinson, 1957; Atkinson & Feather, 1966). Also, students should feel like their efforts are judged righteously, meaning that their success is dependent of their abilities (Keller, 1987, 2010). This is also claimed by Bandura (1977), in his statement on outcome expectations. It is therefore very important that this factor is actively addressed in the learning environment. Students' self-efficacy can be measured by asking students how well they think they will do on a task (Bandura & Schunk, 1981), which is how this will be measured in this study.

B. Value

Values are an individual's beliefs about the reasons for engaging in a task. When students value a task, they are more likely to engage in this task. The core question here is: "Do I want to do this task and why?" (Pintrich & Schunk, 2002, pp. 53). For an individual to engage in a task, this task needs to have a relevance to this person. Relevance "refers to people's feelings or perceptions of attraction toward desired outcomes, ideas, or other people based upon their own goals, motives, and values" (Keller, 2010, pp. 98). This shows that a learning task can be relevant to a student when it suits his or her goals, motives and values. As Newby (1991, pp. 196) mentions, the relevance of the task can be made clear to students by "relating the activity or instruction to the students' interests, future activities, or past experiences in an attempt to show its value and worth." Relevance and value are aspects of (goal) achievement motivation (Atkinson, 1957; Atkinson & Feather, 1966), which indicates that individuals are more motivated to achieve goals that they value.

Also one's interest plays an important role in the attribution of value. When a student is interested in the learning task, thus valuing the learning goal to a higher degree, his/her value for this task (on each of the components) will be higher (Hulleman, Godes, Hendricks & Harackiewicz, 2010; Harp & Mayer, 1997).

Therefore, it's important that students see the relevance of the learning tasks they're engaged in and that they value them, in order to increase their motivation. In fact, Keller (2010) mentions that student motivation decreases severely when students don't see how the learning tasks can be relevant to them.

2. Motivational Design Theory

The current study focuses on how the important motivational areas of self-efficacy and task-relevance can be implemented in the agent's narrative. For this, motivational design strategies are developed, which will be described in the next sections, with some examples of how these are implemented in the agent's narrative. These strategies build on enhancing students' self-efficacy and task-relevance by addressing these in the agent's narrative. Table 1 and 2 show the main components on which the design strategies for enhancing self-efficacy and task-relevance are based.

A. Designing for enhancing self-efficacy

In an instructional motivation design focused on enhancing students' self-efficacy, some factors need to be addressed. The three main aspects for enhancing self-efficacy are: (1) increasing students' belief in their own abilities, (2) emphasizing student control and (3) use appropriate social modeling. These aspects are explained more deeply in the next sections. In Table 1, the instructional motivation strategies for improving self-efficacy are presented.

Table 1. *Strategies for enhancing self-efficacy used in the agent's comments*

Self-efficacy strategy	Design strategy
1. Increase students' belief in their own abilities	*Create positive expectations*
	Focus on student successes that show their ability
	Offer content support
	Encourage students to try
2. Emphasize student control	*Focus on the influence of students' (developing) abilities*
3. Social modeling	*Use coping peer models who overcome learning difficulties*

1. Increase students' belief in their own abilities

1.1 Create positive expectations

First of all, it's important that the students have confidence and believe in their ability to accomplish a task. Therefore, students need to have positive expectations about this task. This can be realized by showing them how they can build on their previous experience and successes to accomplish new task (e.g., show how they succeeded on similar assignments). Emphasizing their abilities and showing them that they have already fulfilled many similar tasks increases their self-efficacy and creates positive expectations about the current (and future) tasks (Bandura, 1977; Wigfield & Eccles, 2000).

1.2 Focus on student successes that show their ability

Also, when students have successfully finished an assignment, it's important to emphasize that this was due to their own ability, competence and effort. It's important to stress that students' efforts are useful and effective, and that learning successes represent their ability (e.g., Bandura, 1977; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). This is also mentioned by Kamins and Dweck (1999), who emphasize that criticizing or praising the students' efforts instead of person traits (such as intelligence, goodness, etc.) is better for their self-worth, might make them recognize their achievements fuller, and promotes a more mastery-oriented response ("which includes high expectations, positive affect, persistence, and stable or improved performance; Diener & Dweck, 1978; Dweck, 1975"). They even state that providing personal feedback (i.e. feedback on person traits) has a negative effect on students' self-worth, because this "involves a global assessment based on a specific behavior or performance" (Kamins & Dweck, 1999, pp. 835), which can make the students more vulnerable (even when te person feedback is positive) and create "a sense of contingent self-worth" (Kamins & Dweck, 1999, pp. 835). This also can lead to helplessness of the students, because their fixed traits (e.g. their intelligence), which they cannot influence, are emphasized. Therefore, they don't have control over the learning situation.

1.3 Offer content support

Thirdly, showing students that they have free access to different resources (e.g. the formula sheet or graphs) that could help them with the assignments will increase their self-efficacy. This option for help creates a safe environment, which will make them more relaxed and increases their self-efficacy. Students don't have to accomplish this task building on their own knowledge only - they can use helpful resources to complete it. Showing students that they have free access to different resources (e.g. the formula sheet or graphs), which are permanently available during the learning task, could help them finishing the assignments more successfully (De Jong & Van Joolingen, 1998; Leutner, 1993, as mentioned in De Jong & Van Joolingen, 1998). This success is still due to their own ability, which is important for earlier mentioned reasons, because students can access these resources at their own preference. They also don't need to feel guilty for using these resources as an extra support, because that's exactly what they're there for.

1.4 Encourage students to try

Lastly, students with low self-efficacy are often apprehensive to try, because they have high expectations for failure (e.g. Covington, as mentioned in Eccles & Wigfield, 2002; Bandura, 1977). It's important that they are encouraged to try, emphasizing that effort is more important than success (Covington, 1992, as mentioned in Eccles & Wigfield, 2002).

2. Emphasize student control

When students believe in their own abilities, the next step is to believe that these abilities influence their learning outcomes. Therefore, they need to be shown that their success is dependent of their abilities (Keller, 1987, 2010; Bandura, 1977).

3. Social modeling

As mentioned earlier, agent Emma represents a social model. This model needs to be appropriate and useful for the learners. As emphasized before, modeling a coping peer student who overcomes the challenges of the learning environment will enhance students' self-efficacy (Zimmerman, 2000). Therefore, the motivational narrative of agent Emma shows phrases that indicate her struggle and overcoming these challenges.

B. Designing for enhancing task-relevance

To enhance students' task-relevance in an instructional motivation design, there are some factors that need to be addressed. The three main aspects for enhancing task-relevance are goal orientation, relating to student value and interest, and relating to student experience and real-life situations. These aspects are explained more deeply in the next sections. In Table 2, the instructional motivation strategies for improving task-relevance are presented.

Table 2. *Strategies for enhancing task-relevance used in the agent's comments*

Task-relevance strategy	Design strategy
1. Goal orientation	*Address how the learning task fits the students' goals*
2. Relate to student interest and value	*Provide choice*
	Model curiosity
3. Relate to student experience and real-life situations	*Show familiarity of the task to students' real-life and experience*

1. Goal orientation

One of the most stressed aspects of increasing the relevance of the task to students is addressing how this task fits with the students' goals. These goals can be related to the students' near future (e.g. a student's goal is to finish the course successfully) or far future plans (e.g. it can be relevant to learn how the human blood circulation system works if the student wants to become a doctor in the future) (Raynor, 1969, 1974, as mentioned in Keller, 2010). The task-relevance for student goals addressed in this narrative is focused on how different elements of the simulation (e.g. the feedback) can attribute to successful results in the simulation. For example, reading the feedback can help the student to answer the next assignment(s) correctly.

2. Relating the learning task to student interest and value

Another important aspect to address when designing to increase students' task-relevance is to show how this task is connected to their personal interests and value (e.g. Keller, 1987, 2010), because students are more motivated to do tasks that fit their interests and values (Atkinson, 1957; Eccles et al., 1983; Eccles & Wigfield, 2002; Eccles, Wigfield, Harold & Blumenfeld, 1993; Wigfield & Eccles, 1992, 2000; Keller, 1987, 2010). One way of addressing this is by providing choices to the students. On a more general level, this could include a choice for, for example, a course or study (e.g. students choosing the courses that they are interested in). However, within the context of this study, this option is inapplicable, because the topic is part of an obligatory course in their curriculum. Therefore, the choice could focus on other aspects, such as choosing to calculate the answer to an assignment in their own preferred way (e.g. using a formula, or deducing the answer from a graph) and choosing to guess the answer instead of calculating or deducing it. Providing choice to students, and thereby individualizing their learning process, increases their value for the chosen option just because this is the option they prefer (Keller, 2010; Wigfield & Eccles, 2002).

Also, to increase student interest, the agent should model curiosity (Keller, 1987, 2010). An agent modeling curiosity can increase students' curiosity. When a student sees someone who is enthusiastic about a topic, or curious to find out more about this, the student could also become curious to find out more about this topic. For sophomore students, curiosity is positively related to both rote learning and comprehension (Caron, 1963, as mentioned in Keller, 2010). Therefore, it's useful to address curiosity in the agent's narrative.

3. Relating the learning task to student experience and real-life situations

Many concepts and terms in the physics field can be very abstract, and can therefore become less relevant to high school students. By relating these concepts to situations that the students encounter in their daily lives and/or have experienced earlier, they become more concrete and thereby also more relevant to them (Keller, 2010; Wigfield & Eccles, 2000). For example, the topic of acceleration can be made more relevant to the students by showing them that they accelerate everyday as they cycle to school. This makes it easier to integrate the new knowledge and skills into their minds and lets them feel that they are no novices in this domain, which could increase their self-efficacy and makes the task more relevant to them.

RESEARCH QUESTIONS AND HYPOTHESES

This study investigates the effects of a motivational agent on student motivation and learning gains in a simulation learning environment. As stated before, it is expected that girls will benefit more from the agent's comments than boys. Therefore, it's useful to investigate also the effects of gender on student motivation.

In this study, both girls and boys will be assigned to one of two conditions: one with motivational agent, and one without. More details about the structure of the study can be found in the *Method* section.

This leads to the following research questions:

1. Is there a difference in student motivation between gender and condition *before* training?

To make sure that student motivation scores during and after training (see research questions 2 and 3, respectively) can be measured correctly, students' initial motivation should be measured. Expected is that girls' initial motivation is lower than that of boys, because of the 'masculine' domain of the learning environment. Female students often have low self-efficacy levels when it comes to learning science or mathematics (e.g. Arroyo, Woolf, Cooper, Burleson & Muldner, 2011; Ceci, Williams & Barnett, 2009; Eccles et al., 1993) and utility of these subjects (i.e. "student's belief that mathematics is valuable to learn" (Eccles et al., 1993; Catsambis, 2005, as mentioned in Arroyo et al., 2011)). This is implied by sociocultural causes, rather than biological causes (Ceci, Williams & Barnett, 2009), because these subjects are accepted as being masculine and girls feel like they should fit their (gender) identity with corresponding gender stereotypes (Nosek, Banaji, & Greenwald, 2002; Kerger, Martin & Brunner, 2011).

2. Is there a difference in student motivation between gender and condition *during* training?

Because of the expected positive effect of the agent on girls' motivation (due to the possibilities to identify with the agent), which was also found in Van der Meij et al.'s (submitted) study, it is expected that girls benefit most from the agent's motivational comments, and that student motivation of girls in the agent condition will increase most. In addition, boys' motivation will increase most in the control condition, without the agent's comments. Expected is that these differences are greater for self-efficacy than for task-relevance.

3. Is there a difference in student motivation between gender and condition *after* training?

It is expected that the motivation of girls in the agent condition will be comparable to that of boys in the control condition after training. The training is designed to raise motivation, especially for girls. The girls should be gaining more from the experience, and hence should level the difference with boys. Based on research by Van der Meij et al. (submitted), it is also expected that after training motivation of girls in the agent condition and boys in the control condition will be higher than that of girls in the control condition and boys in the agent condition, thanks to the possibilities to identify with the agent.

4. Is there a difference in agent appreciation between boys and girls *after* training?

It is expected that all students appreciate agent Emma and her comments. Although her voice is computer-generated, she shows head movements and facial expressions that correspond with her comments. A study by Yan and Agada (2010) showed that most students appreciated a "dramatic" agent (90 percent positive), which is an agent who shows head movements and appropriate facial emotions, that correspond with her verbal expressions.

Furthermore, Kim (2007) mentions that students appreciate gaining task-related information and advice from the agent more than the agent's motivational input. Motivational input is appreciated, but only when this is not just "cheerleading" when students are already self-motivated, as one of the female participants in this study mentioned. Agent Emma's comments are not just "cheerleading", but also focus on useful aspects of the *Motion* environment. This might mean that all students appreciate the agent more.

Previous studies provide no clear statements about differences in agent appreciation between boys and girls. However, as several studies have shown that students appreciate agents that fit their personal characteristics (such as gender, ethnicity and age) more (e.g. Baylor & Kim, 2004; Kim, 2007; Lockwood, 2006; Rosenberg-Kima, Plant, Doerr & Baylor, 2010), it is expected that girls show higher agent appreciation scores.

5. Is there a difference in learning gains between gender and condition?

Based on Van der Meij et al.'s (submitted) study, expected is that students in the agent condition will show the highest learning gains, because the motivational agent would improve learning by motivating the students. It's expected that girls will show the highest learning gains in the agent condition, and boys will learn more in the control condition, thanks to the level of identification with the agent.

However, research by Choi and Clark (2006) shows that the presence of an agent does not always lead to higher student motivation and interest or learning gains. This study showed that the agent leads to significantly higher learning gains for students with the lowest prior knowledge levels. However, it showed no learning gains for students with intermediate or advanced prior knowledge levels. This could indicate that an agent could also distract students from the learning task and can therefore interfere with the agent's positive effects on student motivation.

METHOD

Participants

The participants in this study were 68 ninth grade students (Dutch: derde klas havo), aged between 14 and 16 (*M*=14.76; *SD*=0.58), of which 32 were girls and 36 were boys. The experiment was conducted in three high schools in the Netherlands. Students were randomly assigned to one of the two research conditions, although stratification was applied in order to make sure that a similar distribution for gender was established within the conditions. In each condition, 18 boys and 16 girls participated.

Two participants who started in this study are not included in any analysis, because they did not finish the experiment. For one student, this was due to technical problems and for the other this was due to another training in which this student had to participate.

Materials

A. Learning environment

Motion *Environment*

The participants worked in the *Motion* learning environment, which is a module within *SimQuest* (Van Joolingen & De Jong, 2003). This environment concerns the physics domain of kinematics and focuses on different types of motions and their characteristics. The learning environment consists of three parts that differ in the difficulty of their topics; participants in this study worked only on the second part, which concerns uniformly accelerated motion. This was due to their prior knowledge on kinematics. The learning environment (i.e. part 2 of the *Motion* learning environment in *SimQuest*) includes 29 assignments, which the participants had to finish within 35 minutes. The assignments concern characteristics of the key domain concepts, which are presented in three topics: distance (assignments 1-9), velocity (assignments 10-20) and acceleration (assignments 21-29). For example, students are asked how far a car has driven after a couple of seconds given its velocity. These assignments consist of mostly multiple choice questions, although also some (short) open questions are included. All students were allowed to use standard support instruments, which are a formula sheet, a calculator and pen and paper.

The learning environment interface consists of several graphs, a moving picture of a car (or two cars for some assignments), the assignment and an answering box with either a blank field (for open questions) or multiple choice options. In the agent condition, the APA is added to the interface. Students can zoom in on the graphs and use the simulation to find the answers. After having answered, participants receive immediate textual feedback, whether the answer is correct or incorrect. In most cases, students will have a second or even a third chance to correct an incorrect answer. A screenshot of the simulation is shown in Figure 1.

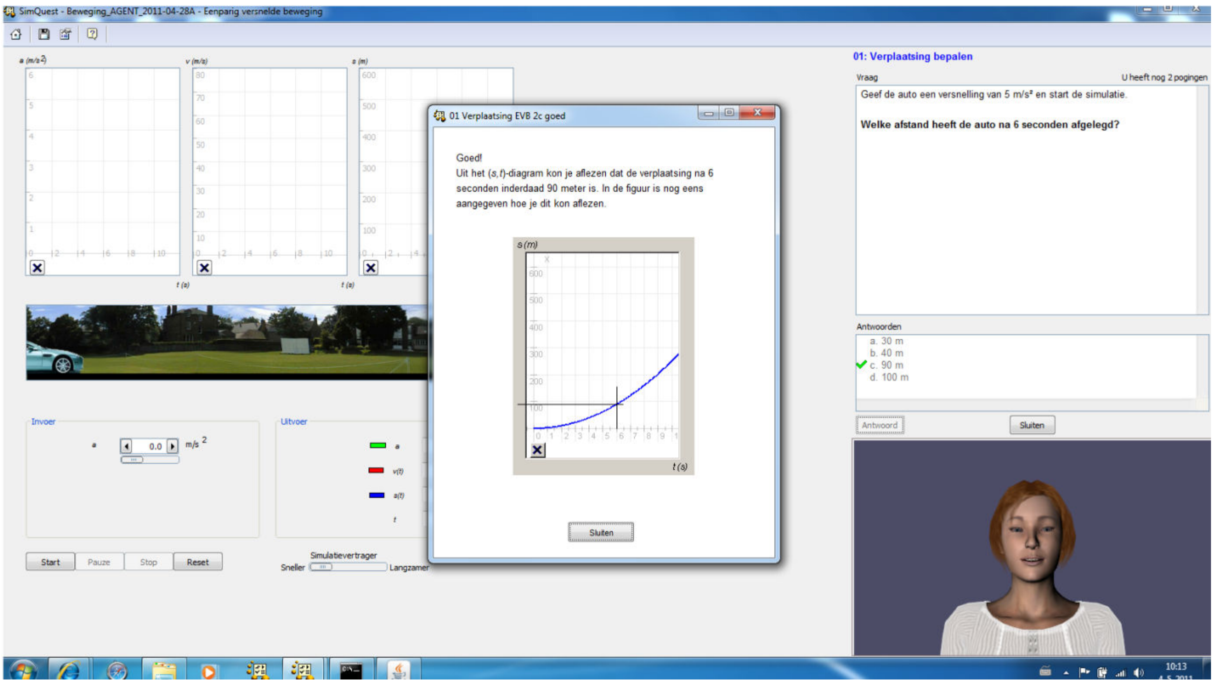


Figure 1. *Screenshot of the* Motion *environment in SimQuest with motivational agent.*

Motivational Agent

In the learning environment, motivational agent Emma was included in the agent condition. Emma was created by combining *SimQuest* (Van Joolingen & De Jong, 2003), the Elckerlyc system for virtual human design (Van Welbergen, Reidsma, Ruttkay & Zwiers, 2010) and the Loquendo speech generator (Loquendo, http://www.loquendo.com). In the learning environment, only Emma's head and shoulders were visible to focus on her motivational comments. Emma showed facial expressions that suited her comments. For example, Emma's eyebrows would lift when she made a comment that showed her surprise. Emma's role was to be a peer student who would go through the simulation in the same way as the students. She therefore had a neutral look (e.g. white shirt, decent haircut). Figure 1 shows a screenshot of the learning environment with agent Emma.

Emma is the same agent that has been used in a study by Van der Meij et al. (submitted), but her motivational comments are new, based on the motivational design framework which has been discussed in the introduction to this study. In the next section, applications of this framework in the agent's comments, including examples, will be discussed. For more details about the design of agent Emma's visual presence, see Van der Meij et al. (submitted).

Emma would start speaking automatically two seconds after a student had opened an assignment or had answered an assignment in the learning environment. The comments always concerned the assignment the student was working on or the feedback that was provided at that moment. The comments were generated by typing texts in the Loquendo speech generator (Loquendo, http://www.loquendo.com), using a standard Dutch female voice. In this generator, there is a limited amount of preset words and expressions to choose from, as well as the possibility to use one's own words and sentences. The preset expressions were very lively and filled with emotion (e.g. Wauw!, Jammer!, Fantastisch!, meaning Wow!, Too bad!, Fantastic!), whereas the self-constructed words and sentences were monotonous. A combination of preset and self-constructed comments was used in the learning environment.

The Agent´s Motivational Comments

As mentioned in the introduction to this study, a framework is developed for designing motivational comments for the agent based on motivational theories. In this section, some examples are provided to illustrate how this theoretical framework for motivational design is implemented in the agent's motivational comments.

For each of these strategies, examples from the agent's comments to enhance self-efficacy and task-relevance are provided in Table 3 and 4 respectively. For example, to encourage students to try, which is part of the self-efficacy strategy to increase students' belief in their own abilities, agent Emma would say: "I think this is a challenging question, but I'll give it another try. Which graph do I need?"

Each of agent Emma's comments is adjusted to the students' activities in the learning environment. For each assignment, comments for agent Emma are designed for four situations: (1) (reading) the assignment; (2) correct answer; (3) incorrect answer; (4) second incorrect answer. When students answered the assignment incorrectly and corrected it, Emma would provide comment (1), (3), (2) respectively. Of course, the comments differ per assignment, taking the context of other assignments within the simulation into account, especially concerning the level of difficulty. For example, Emma sometimes refers to a previous assignment by mentioning:

> *"Hey, this assignment seems exactly like the previous one! I'm sure this one will go well too. Let's just read it carefully."*

This shows that the design is not only focused on the comments per assignment, but also on the narrative of these comments in the simulation learning environment.

Table 3. *Strategies for enhancing self-efficacy used in the agent's comments*

Self-efficacy strategy	Design strategy	Examples in agent narrative
1. Increase students' belief in their own abilities	*Create positive expectations*	Hey, this assignment seems exactly like the previous one! I'm sure this one will go well too. Let's just read it carefully.
	Focus on student successes that show their ability	Yes! How amazing, such an extensive assignment answered correctly at once! It's going well! I deduced that well, hey! This is going very well!
	Offer content support	Hmm, wrong again. Let's read how I could have calculated it. That might be helpful for the next assignments. Look! When the car is driving, you can see how the graph line is drawn, that's handy!
	Encourage students to try	Oh, incorrect. Too bad! I think this is a challenging question, but I'll give it another try! Which graph do I need? Hmm, wrongly deduced! It's about velocity, right? Let's have another look, I'm sure I can do it!
2. Emphasize student control	*Focus on the influence of students' (developing) abilities*	Hmm, sneaky, two questions in one assignment! It doesn't seem too difficult, I think I just have to look at two points on the same graph line. Hmm, that seems difficult! I'm sure I can do it if I look at the graph very precisely.
3. Social modeling	*Use coping peer models who overcome learning difficulties*	That question sounds difficult. It looks like it's two assignments in one! I will calculate them carefully one after another. Oh, still incorrect. Pff! Let's move on quickly. What, incorrect? Let's try a formula then. Pff, this is difficult!

Table 4. *Strategies for enhancing task-relevance used in the agent's comments*

Task-relevance strategy	Design strategy	Examples in agent narrative
1. Goal orientation	*Address how the learning task fits the students' goals*	Right, so I could also have calculated this with a formula. Let me read this [feedback], that might come in handy in a next assignment.
2. Relate to student interest and value	*Provide choice*	I had deducted it from the graph, but apparently I could also have used a formula. Pff… no idea, really! I'll just guess.
	Model curiosity	That's different than a regular class, this simulation! I'm sure this will be alright. Right! Another race with my neighbor. I'm curious to find out who accelerates most.

3. Relate to student experience and real-life situations	***Show familiarity of the task to students' real-life and experience***	Hmm, that looks difficult! Wait a sec, average speed, isn't that what you can see on the speedometer on your bike? Ah, acceleration. That is like when you have to stop for a traffic light and then continue cycling.

B. Instruments

1. Knowledge tests

Pretest

This pretest consists of 27 multiple choice questions with four answer alternatives, which cover different areas of the kinematics domain. The Pretest (in Dutch) is included in Appendix E. For example, students were asked to fill in the missing term in a concept map, to tell what the slope of a v-t graph represents or to find the matching graph to a given situation, as is shown in Figure 2. Participants received a score of 1 point for each correctly answered test item. When they answered an item incorrectly or did not answer, participants scored 0 points. This means that the maximum score on both the pretest and posttest is 27 points.

Posttest

Directly after the experiment, students took a posttest, which was similar to the pretest: it covers the same topics, also consists of 27 multiple choice questions of the same type. However, the items were ordered and formulated differently and were different in their order. The Posttest (in Dutch) is included in Appendix F. The scoring of the posttest is the same as the scoring of the pretest.

2. Motivation questionnaires

There are two types of questionnaires used to measure student motivation: one that is used at three times during the experiment and one that is used after the experiment.

A. Before training

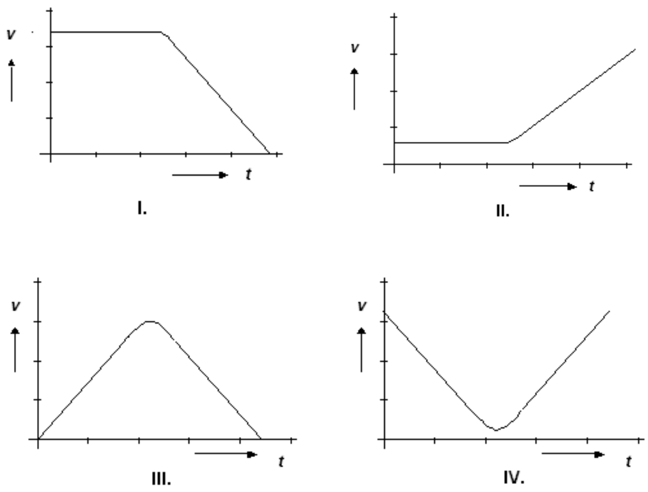
Student motivation was measured once before and twice during the experiment by asking students two questions:

1) *How well do you think you will do on the next assignments?*
2) *How relevant are these topics to you?*

Students were asked to mark their level of self-efficacy (question 1) and task-relevance (question 2) on a 10 centimeter line that was presented with the question. The endpoint anchors showed extremes dependent of the question posed, for example *not relevant at all – very relevant*; *not well at all – very well*. The number of millimeters on the line (from left to right) equaled their initial self-efficacy and task-relevance scores. For example, when students marked their task-relevance at 56 millimeters, their task-relevance score was 56 (out of 100). The complete Motivation Questionnaire During Training (in Dutch) is included in Appendix A.

17.
Look closely at the four v-t graphs that are shown below. Which of the graphs matches the following situation best?

"The rollercoaster carts are pulled up with constant engine power to the highest point of the roller coaster. From that point, the rollercoaster carts quickly move downwards."



☐ Graph I
☐ Graph II
☐ Graph III
☐ Graph IV

Figure 2. *Example of a posttest question*

B. During training

After assignments 10 and 21, which are the first assignments of a new topic, students are asked the same questions mentioned before (see *Before training*). The answering options and scoring are the same as those used in the *before training* questionnaire.

C. After training

In the *after experiment questionnaire*, the same questions as those in the *during experiment questionnaire* were posed, but the context of these questions was different. In the introduction was mentioned that students should imagine that they were about to do some more assignments on each of the three topics. For each of the three topics in the simulation, students were asked to mark their level of task-relevance and self-efficacy in the same way as they did during the experiment. For example, students were asked how well they would think they would finish the next assignments, imagining that they would cover the topic of velocity and having already done some assignments on this topic. The three measuring items provide information about the students' self-efficacy (i.e., SEafter1, SEafter2, SEafter3) and task-relevance (i.e., TRafter1, TRafter2, TRafter3) levels after training on each of the three topics. The scoring of these values is the same as for the *during* *experiment questionnaire*. Students' mean motivation scores after training (i.e. SEafter, which is the mean of SEafter1, SEafter2 and SEafter3, and TRafter, which is the mean of TRafter1, TRafter2 and TRafter3) will be used in the analyses. The complete Motivation Questionnaire After Training (in Dutch) is included in Appendix B.

3. Questionnaires on Mood and Cognitive Load

To investigate students' mood and cognitive load during training, they were asked two questions on a paper form: "How do you feel after this task?" *(mood)* and "How hard did you think this task was?" *(cognitive load)*. For expressing their moods, students were asked to express their current affective states by selecting one of five emotions (happy, secure, neutral, insecure, sad). This type of measurement was also used by Kim and Baylor (2007). For expressing their cognitive load, students were asked to mark their cognitive loads on a 10 centimeter line. The anchors showed the extremes of "very hard" to "very easy". The number of millimeters on the line (from left to right) equaled their cognitive load scores, where a higher score indicates a lower cognitive load. The Mood and Cognitive Load Questionnaire (in Dutch) is included in Appendix C. Data from these questionnaires have not been analyzed in this study due to time restrictions.

4. Agent Questionnaire

To investigate whether the participants could relate to agent Emma's comments and appreciate the agent, participants in the agent condition were asked to express how they feel about these comments. They were asked to react to 11 statements about Emma's comments, for example "I could imagine why Emma made these comments", "I liked Emma's comments", "Emma said what I was thinking" and "Emma stimulated me to keep going". Students marked a cross on a 10 centimeter line to indicate whether this statement was not valid for them at all (0 centimeter) or completely in line with their thoughts (10 centimeter). For most statements, the following was true: the higher their score on this line, the higher their value of Emma's comments. However, the opposite was true for the negatively formulated statements. The Agent Questionnaire (in Dutch) is included in Appendix D.

C. Procedure

A week prior to the experiment, students took a pre-test (see *Instruments*), for which they had a maximum of 20 minutes to complete. Students worked individually on this test in a classroom setting.

The experiment took place in a quiet place at the students' schools. During the experiment, a researcher was present to assist the students when needed and to provide instruction. All students worked individually throughout the training.

At the start of the experiment, students received a 2 minute instruction from the researcher. In this instruction was explained how the simulation worked (e.g. how to change variables, how to select an answer) and that the students would have to fill out some questionnaires throughout the experiment whenever the simulation asked them so. An additional instruction was provided for students in the agent condition, in which was explained that Emma, the agent, is a fellow student who would comment on the simulation and that it's important to listen to her and let her finish whenever she's speaking.

Students would work in the learning environment for a period of maximum 35 minutes. This includes filling out the motivational questionnaires (see *Instruments*) before, during and after the experiment and the questionnaires on mood and cognitive load (see *Instruments*). The *Motivation Questionnaires Before and During Training* were presented after each first assignment of a new topic within the domain (i.e. assignment 1, 10, 21). After the last assignment (i.e. assignment 29) students filled out the *Motivation Questionnaire After Training* (see *Instruments*). Beside this, students were asked to fill out forms on which they mention their moods and cognitive load every 10 to 15 minutes.

Directly after the students had finished working with the simulation, they started working on the posttest (see *Instruments*), which they had to finish within 20 minutes. Students in the agent condition first filled out the *Agent Questionnaire* (see *Instruments*) and then started working on the posttest.

D. Methods for Data Analysis

To investigate students' learning gains, their posttest scores will be compared to their pretest scores. Therefore, their difference scores will be used for analysis. This same method will be used for examining students' motivation after training. In this case, the mean motivation for both self-efficacy and task-relevance on the after training motivation questionnaire will be compared to their initial self-efficacy and task-relevance scores. To examine students' increase in motivation during training, analyses of variance will be used as well. At each moment during training (i.e. t2 and t3), student's motivational scores will be compared to their initial motivation scores.

In all analyses, significance is set at an α of 0.05 (two-tailed). Trends ($0.05 < p > 0.10$) will only be mentioned when they show effects in the expected direction. To report effect size, Cohen's (1988) *d* will be used, with $d = 0.2$ showing a small effect size; $d = 0.5$ showing a medium effect size; and $d = 0.8$ showing a large effect size.

RESULTS

1. Is there a difference in student motivation between gender and condition *before* training?

Analyses of variance show no differences between condition ($F<1$) and no interaction effect between gender and condition ($F<1$) for self-efficacy. However, a difference between gender was found ($F(1,67)=3.74$, $p=.057$). Girls' self-efficacy beliefs are initially lower than boys'. Students' initial self-efficacy scores per condition and gender are presented in Table 5.

Also for task-relevance, no differences between condition ($F<1$) and no interaction effect between gender and condition ($F<1$) were found. A difference between gender was found ($F(1,67)=3.78$, p=.056). Girls' task-relevance beliefs are initially lower than boys'. Students' initial task-relevance scores per condition and gender are presented in Table 6.

Table 5. *Self-efficacy scores before, during and after training per condition and gender.*

Measure	**Condition**	**Gender**		
		Girls M (SD)	Boys M (SD)	*Total* *M (SD)*
Initial SE	Agent	37,31 (17,63), N=16	54,72 (24,19), N=18	*46,53 (22,82), N=34*
	Control	44,40 (25,63), N=15	46,94 (23,79), N=18	*45,79 (24,28), N=33*
	Total	*40,74 (21,79), N=31*	*50,83 (23,97), N=36*	*46,16 (23,37), N=67*
SE During 1	Agent	54,94 (19,29), N=16	60,00 (20,11), N=18	*57,62 (19,60), N=34*
	Control	59,13 (24,31), N=15	64,00 (17,62), N=18	*61,79 (20,72), N=33*
	Total	*56,97 (21,59), N=31*	*62,00 (18,74), N=36*	*59,67 (20,12), N=67*
SE During 2	Agent	54,25 (19,90), N=16	60,33 (15,93), N=18	*57,47 (17,89), N=34*
	Control	59,53 (24,32), N=15	69,83 (11,69), N=18	*65,15 (18,93), N=33*
	Total	*56,81 (21,93), N=31*	*65,08 (14,59), N=36*	*61,25 (18,68), N=67*
SE After	Agent	53,90 (18,96), N=16	60,00 (10,07), N=18	*57,13 (15,01), N=34*
	Control	54,92 (22,73), N=16	67,00 (19,16), N=18	*61,31 (21,48), N=34*
	Total	*54,41 (20,60), N=32*	*63,50 (15,49), N=36*	*59,22 (18,51), N=68*

N.B. The maximum self-efficacy score is 100. A higher score means more motivation

Table 6. *Task-relevance scores before, during and after training per condition and gender.*

Measure	**Condition**	**Gender**		
		Girls M (SD)	Boys M (SD)	*Total* *M (SD)*
Initial TR	Agent	36,50 (24,68), N=16	50,06 (23,56), N=18	*43,68 (24.70), N=34*
	Control	44,27 (19,77), N=15	50,67 (25,62), N=18	*47,76 (23,02), N=33*
	Total	*40,26 (22,42), N=31*	*50,36 (24,26), N=36*	*45,69 (23,80), N=67*
TR During 1	Agent	49,50 (23,90), N=16	54,00 (22,31), N=18	*51,88 (22,83), N=34*
	Control	53,20 (21,37), N=15	59,28 (16,50), N=18	*56,52 (18,81), N=33*
	Total	*51,29 (22,41), N=31*	*56,64 (19,52), N=36*	*54,16 (20,92), N=67*

TR During 2	Agent	45,88 (25,68), N=16	48,78 (22,85), N=18	*47,41 (23,89), N=34*
	Control	55,00 (21,07), N=15	60,39 (21,92), N=18	*57,94 (21,38), N=33*
	Total	*50,29 (23,63), N=31*	*54,58 (22,84), N=36*	*52,60 (23,13), N=67*
TR After	Agent	40,00 (21,37), N=16	48,67 (20,26), N=18	*44,59 (20,94), N=34*
	Control	53,79 (21,73), N=16	59,74 (20,15), N=18	*56,94 (20,81), N=34*
	Total	*46,90 (22,33), N=32*	*54,20 (20,69), N=36*	*50,76 (21,63), N=68*

N.B. The maximum task-relevance score is 100. A higher score means more motivation

2. Is there a difference in student motivation between gender and condition *during* training?

Self-efficacy

Analyses of Variance for *SE During 1* with *Initial SE* as a covariate show no differences between gender ($F<1$), condition ($F<1$) and no interaction effect between gender and condition ($F<1$) on self-efficacy. However, the *Initial SE* showed significant influence ($F(1,66)=17.82$, $p=.00$).

Analyses of Variance for *SE During 2* with *Initial SE* as a covariate show no differences between gender ($F<1$), and no interaction effect between gender and condition ($F(1,67)=1,61$, n.s.). However, a significant difference between condition ($F(1,67)=4.40$, $p<.05$) was found. Students in the control condition showed higher self-efficacy scores than students in the agent condition. Also, *Initial SE* showed significant influence ($F(1,66)=17.82$, $p=.00$).

Students' self-efficacy scores during training per condition and gender are presented in Table 5.

Task-relevance

Analyses of Variance for *TR During 1* with *Initial TR* as a covariate show no differences between gender ($F<1$), condition ($F<1$) and no interaction effect between gender and condition ($F<1$) on task-relevance. However, the *Initial TR* showed significant influence ($F(1,66)=55.60$, $p=.00$).

Analyses of Variance for *TR During 2* with *Initial TR* as a covariate show no differences between gender ($F<1$), and no interaction effect between gender and condition ($F<1$). However, a trendwise difference was found for condition ($F(1,67)=3.08$, $p=.08$). Students in the control condition showed higher task-relevance scores than students in the agent condition. Perceptions of task-relevance increased more for girls than for boys. Also, *Initial TR* showed significant influence ($F(1,67)=53.66$, $p=.00$).

Students' task-relevance scores during training per condition and gender are presented in Table 6.

3. Is there a difference in student motivation between gender and condition *after* training?

Self-efficacy gains

Difference score analysis shows no differences between conditions ($F<1$) or gender ($F<1$). An interaction effect trend was found between gender and condition in the expected direction ($F(1,67)=3.64$, $p=.06$). Girls show higher self-efficacy scores in the agent condition, and boys show higher self-efficacy scores in the control condition. All students show gains on self-efficacy. Students' self-efficacy scores after training are presented in Table 5. Table 7 shows the self-efficacy gains per condition and gender.

Table 7. *Self-efficacy gains per condition and gender.*

Condition	Self-efficacy gains		
	Girls M (SD)	**Boys M (SD)**	***TOTAL M (SD)***
Agent	16,58 *(18,53),* N=16	5,38 *(23,72),* N=18	*10,60 (21,88), N=34*
Control	12,29 *(22,15),* N=16	20,06 *(17,13),* N=18	*16,40 (19,74), N=34*
Total	*14,44 (20,21), N=32*	*12,67 (21,73), N=36*	*13,50 (20,89), N=68*

N.B. The maximum self-efficacy score is 100.

Task-relevance gains

Difference score analysis shows no differences between gender (*F*<1) and no interaction effect between condition and gender (*F*<1). However, a significant difference between condition was found (*F*(1,67)=6.08, *p*<.05, *d*=0.61). Students in the control condition showed significantly higher task-relevance gains. Students' task-relevance scores after training are presented in Table 6. Table 8 shows the task-relevance gains per condition and gender.

Table 8. *Task-relevance gains per condition and gender.*

Condition	Task-relevance gains		
	Girls M (SD)	**Boys M (SD)**	***TOTAL M (SD)***
Agent	3,50 *(18,97),* N=16	-1,39 *(12,61),* N=18	*0,91 (15,87), N=34*
Control	12,29 *(16,71),* N=16	9,07 *(15,80),* N=18	*10,59 (16,07), N=34*
Total	*7,90 (18,14), N=32*	*3,84 (15,05), N=36*	*5,75 (16,58), N=68*

N.B. The maximum task-relevance score is 100.

4. Is there a difference in agent appreciation between boys and girls *after* training?

Analyses show a significant difference between gender (*F*(1,33)=4.92, *p*<.05, *d*=0.77). Girls appreciate the agent more than boys. Students' agent appreciation scores are presented in Table 9.

Table 9. *Agent appreciation scores per gender.*

	Girls M (SD)	**Boys M (SD)**	***TOTAL M (SD)***
Agent Appreciation Score	54,49 (13,32) N=16	40,58 (21,69) N=18	*47,13 (19,31) N=34*

N.B. The maximum agent appreciation score is 100. A higher score indicates higher appraisal.

5. Is there a difference in learning gains between gender and condition?

Analyses show a significant difference between conditions ($F(1,62)=7.23$, $p<.01$, $d=0.62$). Students in the control condition showed significantly higher learning gains than students in the agent condition. This shows that the agent has a significantly negative effect on the learning gains of both boys and girls. This result contradicts the hypothesis that the agent would increase students' learning gains. However, despite the hindering factor of the agent, all students showed significant learning effects ($p<.05$), regardless of their gender or experimental condition.

Analyses also show a significant difference between gender ($F(1,62)=6.04$, $p<.05$, $d=0.56$). Girls showed significantly higher learning gains. Analyses show no interaction effect between condition and gender ($F<1$). The pretest and posttest scores per condition and gender are presented in Table 10.

Table 10. *Mean scores and standard deviations for the pretest and posttest per condition and gender.*

	Pretest			**Posttest**		
Condition	Girls M (SD)	Boys M (SD)	*TOTAL* *M (SD)*	Girls M (SD)	Boys M (SD)	*TOTAL* *M (SD)*
Agent	7,56 (2,67) N=16	7,31 (1,99) N=16	*7,44 (2,31)* *N=32*	8,94 (2,46) N=16	9,12 (2,03) N=17	*7,97 (2,81)* *N=32*
Control	7,00 (2,08) N=14	7,53 (2,96) N=17	*7,29 (2,57)* *N=31*	11,43 (3,32) N=14	7,00 (2,88) N=16	*10,16 (2,89)* *N=31*
Total	*7,30 (2,38)* *N=30*	*7,42 (2,50)* *N=33*	*7,37 (2,43)* *N=63*	*10,10 (3,11)* *N=30*	*8,09 (2,66)* *N=33*	*9,05 (3,03)* *N=63*

N.B. The maximum test score on both the pretest and posttest is 27.

DISCUSSION

This study investigated the effect of an animated pedagogical agent on student motivation and learning gains in a simulation-based learning environment. Girls' initial motivation was found to be lower than that of boys. After completing two-thirds of the training, students in the control condition gave significantly higher appraisals for self-efficacy than students in the APA condition. In addition, girls expressed higher perceptions of task-relevance than boys effect of gender on task and condition. After training, an interaction effect showed that the self-efficacy of girls had increased most in the APA condition while self-efficacy of boys increased most in the control condition. This interaction effect coincides with a higher appreciation of the agent by the girls. For task-relevance a main effect of condition was found, in favor of the control condition. For knowledge gains there were main effects for condition and gender. The control condition yielded more learning gains than the APA condition, and girls learned more than boys.

By and large, the results showed that girls appreciated the APA more than boys, and that girls mostly benefited from the agent, while boys' motivation was higher in the control condition. These findings could indicate that those who value the agent the most are mostly affected by her comments. As the agent positively affects girls, the question rises why boys reacted differently to the agent than girls. In the following sections we argue that the following factors may have been influential: initial motivation, internal properties of the agent (or: the strategies used to design the agent), and the external properties of the agent.

A. Initial motivation

Students' initial motivation defined their motivation during training, whereas their gender and condition had no effect. Students with higher initial motivation would probably need the motivational agent less than students with lower initial motivation. As boys' initial motivation was higher, they may therefore have needed the agent less than girls. This might have caused the boys to take the agent less seriously, because they already are motivated and the agent might bother their motivation. This might also decrease their interest in the learning task, because the focus of the support in the learning task is on student motivation.

B. Internal properties of the agent: the strategies

The negative influence of the agent on boys may also have been caused by the agent's internal properties, or motivational comments. These comments have primarily been designed following a newly developed instructional motivation design theory which combines the ARCS Model (Keller, 1987; 2010) with expectancy-value theory (Eccles et al., 1983; Eccles & Wigfield, 2002; Eccles, Wigfield, Harold & Blumenfeld, 1993; Wigfield & Eccles, 1992, 2000), and self-efficacy theory (Bandura, 1977). For Emma's credibility, it's important that students can imagine that a peer student would say this about the assignments. This was tested and confirmed during the pilot study. However, as results showed positive effects of the agent on girls, and not on boys, maybe the strategies have not been effective for boys. Perhaps the strategies have focused too much on girls, which lead to lower interest and appreciation by boys.

The strategies that were used to enhance students' *self-efficacy* were based on three main aspects: increase students' belief in their own abilities; emphasize student control; and social modeling. The specific strategies included in the first and second category (creating positive expectations for the students; focusing on student successes that show their ability; offering content support; encouraging students to try; and focusing on the influence of students' (developing) abilities) do not seem feminine or masculine in their nature. However, the strategy of using coping peer models who overcome learning difficulties might be less useful for boys, as they showed higher initial self-efficacy and task-relevance beliefs which shows that they are not coping students themselves. This might have made it harder for them to identify themselves with the agent, as the agent was a coping peer student. In their evaluation of the agent, boys mentioned that they did not feel the same way as the agent did about the assignments, whereas girls mentioned the opposite.

Beside this, a difficult aspect of designing the motivational comments has been the risk of providing unearned praise. After a correct answer, the agent mostly praises the students (or, actually, herself), although she sometimes addresses guessing ("Ha! I guessed the right answer. Nice!"). Students could have been guessing the correct answer when they were praised for their effort, which would mean that they received unearned praise. Someone who provides unearned praise to a student reduces his or her credibility and effectiveness of future praise that is provided by this person (Pintrich & Schunk, 2002). Also, it may seem that complimenting the student is just routine, which makes the students take Emma less seriously (Margolis & McCabe, 2006). This could be taken into account in a future research setting, in a way that the agent (or: the software) would know when participants are guessing, and when their answer is not a guess, and adjust the agent's comments to this situation.

The strategies that were used to enhance students' *task-relevance* were also based on three main aspects: goal orientation; relate to student interest and value; and relate to student experience and real-life. The design strategies (address how the learning task fits the students' goals; provide choice; model curiosity; and show familiarity of the task to students' real-life and experience) do not seem feminine or masculine in their nature. Therefore, it seems more plausible to attribute the differences in effect of the agent on boys and girls to their initial motivation. As the tasks already seemed relevant to boys before training, they could take the agent's comments addressing task-relevance less seriously, making the agent less credible in representing their own characteristics as a student.

C. External properties

Possibly, boys could not relate very well to the agent because of her external properties. She might externally not have been credible to boys as a human interactor or representing the characteristics of the male participants.

Firstly, as mentioned before, maybe the agent’s role of coping peer student might have lessened her influence on boys, as they were not coping students. This indicates that her role did not represent the characteristics of the male participants.

Also, the agent’s voice may not have been credible because it was a computerized voice (Lester, Callaway, Gregoire, Stelling, Towns, & Zettlemoyer, 2001), due to time and cost restrictions. A human voice would have made the agent more credible, which would have increased her influence on student motivation and learning. Atkinson, Mayer and Merrill (2005) pointed out that that using a human voice leads to better scores on retention, near transfer and far transfer, which indicates that the learning gains in the agent condition could have been higher if agent Emma had had a human voice.

Although a study by Lockwood (2006) showed that the agent’s gender was less important for boys, these results may not have been replicated in this study. Possibly a male agent may have appealed more to boys as their genders match. In this study was, however, not investigated whether boys preferred an agent of the same gender.

Lastly, another factor that might be taken into account in future research, which might especially be beneficial for students with low self-efficacy beliefs, is the question to whom students compare their achievements. As Emma is a peer to the students, and her actions and achievements are always present for them, students compare their achievements to Emma's, instead of to their own accomplishments. For students with low self-efficacy beliefs, this can be disappointing, discouraging and dysfunctional (Margolis & McCabe, 2006). To establish standards that are realistic for each student, and thereby improving their self-efficacy, students should only compare their actions to their own previous performances rather than other's achievements. Another possibility for students with low-efficacy levels is to implement an agent who is less intelligent than the students. Studies by Baylor and Kim (Baylor & Kim, 2004; Baylor & Kim, 2005; Kim & Baylor, 2006) have indicated that students' self-efficacy scores increase when they perceive the motivational agent as less intelligent. This has not been taken into account in this study, because agent Emma was designed to have a similar level of intelligence to the students, as if she were a peer student in their own class. In future research, an agent with a lower level of intelligence could be used to increase students' self-efficacy even more.

Focusing on motivation or learning?

Another question that emerges is that of the agent's effects on learning. Surprisingly, analyses showed higher learning gains for students in the control condition than students in the agent condition. This could indicate that the agent is a distracting factor when students are focusing on learning. The strategies used for designing agent Emma focused mainly on motivation, although content support was offered as well. As Emma's comments were focused on motivation, this could have caused the students to focus less on the content of the simulation. Agent Emma's comments are primarily designed to enhance student motivation, and not their learning gains. However, when using an agent in an educational setting, it would be beneficial to also have students learn something when working in the learning environment, instead of just being motivated.

This raises the question whether it is more important to motivate students for the learning task, or to have them focus on the learning task. Agent Emma did not merely focus on motivation; as, for example, Table 3 shows, one of the design strategies to increase self-efficacy is to offer content support. Although agent Emma did draw attention to the content, her positive effects on learning failed to occur. Therefore, drawing students' attention mainly to their motivation for the learning tasks, instead of to the content, as agent Emma did, might not be the best option when implementing an agent in a learning environment.

Possibly, a different balance in the agent's comments could change this effect. When the motivational agent's comments focus more on the content than was done in this study, while keeping a certain minimum of comments addressing student motivation, the agent might have influenced students' learning positively. Perhaps integrating the learning strategy to "offer content support" in the agent's comments more often, giving less attention to other strategies, could positively affect students' learning gains.

Also, the timing of agent Emma's comments could be adjusted to have the students focus more on the assignments. In this study, the agent automatically started talking two seconds after the students had opened the assignment, which might have been just when students were reading the assignment. Therefore, agent Emma could have interrupted their reading of the assignment, so that students were reading the assignment less carefully. A more natural timing, not interrupting the students' reading, could have made a positive difference.

As agent Emma's voice was computerized, not all her comments were pronounced with an expressive voice. As mentioned before, only some standard expressions in the Loquendo speech generator have been pronounced with. Research by Veletsianos (2009) showed that an expressive voice leads to higher retention scores. Possibly, if agent Emma's voice had been more expressive, she would have had a positive influence on learning.

On the other hand, one might argue that - considering the balance between motivational support and learning support - it is important to realize that motivation is an important prerequisite for learning, and also "significantly influences learning resources" (Astleitner & Wiesner, 2004). This indicates that if student motivation is established first, their learning will follow later. Whether this is true might be investigated in future studies. Possibly, girls will start to learn more about the domain later, when their self-efficacy beliefs have been established on a higher level.

REFERENCES

Arroyo, I., Woolf, B. P., Cooper, D. G., Burleson, W., & Muldner, K. (2011, 6-8 July). *The impact of animated pedagogical agents on girls' and boys' emotions, attitudes, behaviors and learning.* Paper presented at the 11th IEEE International Conference on Advanced Learning Technologies (ICALT), Athens, Georgia.

Astleitner, H. & Keller, J. M. (1995). A Model for Motivationally Adaptive Computer-Assisted Instruction. *Journal of Research on Computing in Education, 27* (3), 270-280.

Astleitner, H. & Wiesner, C. (2004). An Integrated Model of Multimedia Learning and Motivation. *Journal of Educational Multimedia and Hypermedia, 13*(1), 3-21.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review, 64*(6p1), 359-372.

Atkinson, J. W. & Feather, N. T. (Ed.) (1966). A theory of achievement motivation. New York: Wiley.

Atkinson, R. K. (2002). Optimizing learning from examples using animated pedagogical agents. *Journal of Educational Psychology, 94,* 416–427.

Atkinson, R. K., Mayer, R. E., & Merrill, M. M. (2005). Fostering social agency in multimedia learning: Examining the impact of an agent‘s voice. *Contemporary Educational Psychology*, 30, 117–139.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. & Schunk, D. H. (1981). Cultivating Competence, Self-Efficacy, and Intrinsic Interest Through Proximal Self-Motivation. *Journal of Personality and Social Psychology, 41*(3), 586-598.

Baylor, A. L. & Kim, Y. (2004). *Pedagogical Agent Design: The Impact of Agent Realism, Gender, Ethnicity, and Instructional Role.* Paper presented at the Intelligent Tutoring Systems, Maceió, Alagoas, Brazil.

Baylor, A. L., & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education, 15*, 95-115.

Ceci, S. J., Williams, W. M. & Barnett, S. M. (2009). Women’s Underrepresentation in Science: Sociocultural and Biological Considerations. *Psychological Bulletin*, *135*(2), 218–261.

Choi, S. & Clark, R. E. (2006). Cognitive and Affective Benefits of an Animated Pedagogical Agent for Learning English as a Second Language. *Journal of Educational Computing Research, 34*(4), 441-466.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Craig, S. D., Gholson, B., & Driscoll, D. M. (2002). Animated pedagogical agents in multimedia educational environments: Effects of agent properties, picture features, and redundancy. *Journal of Educational Psychology*, *94(2),* 428–434.

de Jong, T., & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*, 179-201.

de Jong, T., van Joolingen, W. R., Veermans, K., & van der Meij, J. (2005). Authoring discovery learning environments: In search for reusable components. In J. M. Spector & D. A. Wiley (Eds.), *Innovations in instructional technology: Essays in honor of M. David Merrill* (pp. 11-28). Mahwah, NJ: Erlbaum.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco, CA: W. H. Freeman.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109-132. doi: 10.1146/annurev.psych.53.100901.135153

Eccles, J.S., Wigfield, A., Harold R.D., & Blumenfeld, P. (1993). Age and gender differences in children's self and task perceptions during elementary school. *Child development, 64,* 830-847.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences, 8,* 391–450. doi:10.1207/ s15327809jls0803&4_3

Graesser, A. & McNamara, D. (2010). Self-Regulated Learning in Learning Environments With Pedagogical Agents That Interact in Natural Language. *Educational Psychologist, 45*(4), 234-244.

Gulz, A. & Haake, M. (2006). Design of animated pedagogical agents - A look at their look. *International Journal of Human-Computer Studies, 64,* 322–339.

Harp, S. F. & Mayer, R. E. (1997). The Role of Interest in Learning From Scientific Text and Illustrations: On the Distinction Between Emotional Interest and Cognitive Interest. *Journal of Educational Psychology*, *89*(1), 92-102.

Heidig, S. & Clarebout, G. (2011). Do pedagogical agents make a difference to student motivation and learning? *Educational Research Review, 6,* 27–54.

Hulleman, C. S., Godes, O., Hendricks, B. L. & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention, *Journal of Educational Psychology, 102*(4), 880–895. doi: 10.1037/a0019506

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, *38*(1), 32–132.

Kamins, M. L. & Dweck, C. S. (1999). Person Versus Process Praise and Criticism: Implications for Contingent Self-Worth and Coping. *Developmental Psychology, 35*(3), 835-847.

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development, 10*(3), 2-10.

Keller, J. M. (2010). *Motivational design for learning and performance. The ARCS model approach*. New York, NY: Springer Verlag.

Kerger, S., Martin, R. & Martin Brunner, M. (2011). How can we enhance girls' interest in scientific topics? *British Journal of Educational Psychology, 81,* 606–628.

Kim, Y. (2007). Desirable characteristics of learning companions. *International Journal of Artificial Intelligence in Education, 17*(4), 371-388.

Kim, Y. & Baylor, A. L. (2006). Pedagogical agents as learning companions: the role of agent competency and type of interaction. *Educational Technology, Research and Development*, *54,* 223–243.

Kim, Y., & Baylor, A. L. (2007). Pedagogical agents as social models to influence learner attitudes. *Educational Technology, 47*(1), 23-28.

Lester, J., Callaway, C., Gregoire, J., Stelling, G., Towns, S. & Zettlemoyer, L. (2001). Animated pedagogical agents in knowledge-based learning environments. In: Forbus, K. & Feltovich, P. (Eds.), *Smart Machines in Education*. AAAI/MITPress: Menlo Park, CA, pp. 269–298.

Lockwood, P. (2006). "Someone like me can be successful": Do college students need same-gender role models? *Psychology of Women Quarterly, 30,* 36–46.

Margolis, H. & McCabe, P. P. (2006). Improving Self-Efficacy and Motivation: What to Do, What to Say, *Intervention in School and Clinic, 41*(4), 218-227.

Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction, 13* (2), 125–139.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist, 59*(1), 14-19. doi: 10.1037/0003-066x.59.1.14

Mayer, R. E. (2005). Principles of multimedia learning based on social cues: Personalization, voice, and image principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning*, pp. 201-214. Cambridge: Cambridge University Press.

Newby, T. J. (1991). Classroom Motivation: Strategies of First-Year Teachers*. Journal of Educational Psychology, 83*(2), 195-200.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology*, 83, 44–59. doi:10.1037/0022-3514.83.1.44

Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education. Theory, research and applications* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall Merrill.

Pintrich, P. R., & Schunk, D. H. (2002). *Motivation in education. Theory, research and applications* (2nd ed.). Upper Saddle River, NJ: Pearson Education.

Rosenberg-Kima, R. B., Baylor, A. L., Plant, E. A. & Doerr, C. E. (2008). Interface agents as social models for female students: The effects of agent visual presence and appearance on female students' attitudes and beliefs, *Computers in Human Behavior, 24,* 2741–2756.

Schunk, D. H. (2003). Self-efficacy for reading and writing: Influence of modeling, goal setting, and self-evaluation. *Reading and Writing Quarterly, 19*, 159-172.

Schunk, D. H., & Hanson, A. R. (1989). Influence of peer-model attributes on children's beliefs and learning. *Journal of Educational Psychology, 81,* 431–434.

Schunk, D. H., Hanson, A. R., & Cox, P. D. (1987). Peer-model attributes and children's achievement behaviors. *Journal of Educational Psychology, 79,* 54–61.

Van der Meij, H., Van der Meij, J. & Harmsen, R. (submitted). Animated Pedagogical Agents: Do they enhance student motivation and learning in an inquiry learning environment?

van Welbergen, H., Reidsma, D., Ruttkay, Z. M., & Zwiers, J. (2010). Elckerlyc, a BML Realizer for continuous, multimodal interaction with a virtual human. *Journal on Multimodal User Interfaces, 3*(4), 271-284.

Joolingen, W.R. van, & Jong, T.de (2003). SimQuest, authoring educational simulations. *In: T. Murray, S. Blessing, S. Ainsworth: Authoring Tools for Advanced Technology Learning Environments: Toward cost-effective adaptive, interactive, and intelligent educational software.* pp. 1-31. Dordrecht: Kluwer

Veermans, K., van Joolingen, W. & de Jong, T. (2006). Use of Heuristics to Facilitate Scientific Discovery Learning in a Simulation Learning Environment in a Physics Domain. *International Journal of Science Education, 28*(4), 341 – 361. doi 10.1080/09500690500277615

Veletsianos, G. (2009). The impact and implications of virtual character expressiveness on learning and agent–learner interactions. *Journal of Computer Assisted Learning, 25,* 345–357.

Wigfield & Eccles (2000). Expectancy–Value Theory of Achievement Motivation. *Contemporary Educational Psychology, 25***,** 68–81. doi:10.1006/ceps.1999.1015

Wigfield, A. & Eccles, J. S. (2002). *The Development of Achievement Motivation.* San Diego, CA: Academic Press.

Yan, J. & Agada, R. (2010). *Methods of Improving Communications by a Life-Like Animated Pedagogical Agent.* Paper presented at the 10th IEEE International Conference on Computer and Information Technology (CIT 2010), Bradford, West Yorkshire, UK.

Zimmerman, B. J. (2000). Attaining self-regulation. A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds*.), Handbook of selfregulation* (pp. 13–39). San Diego, CA: Academic Press.

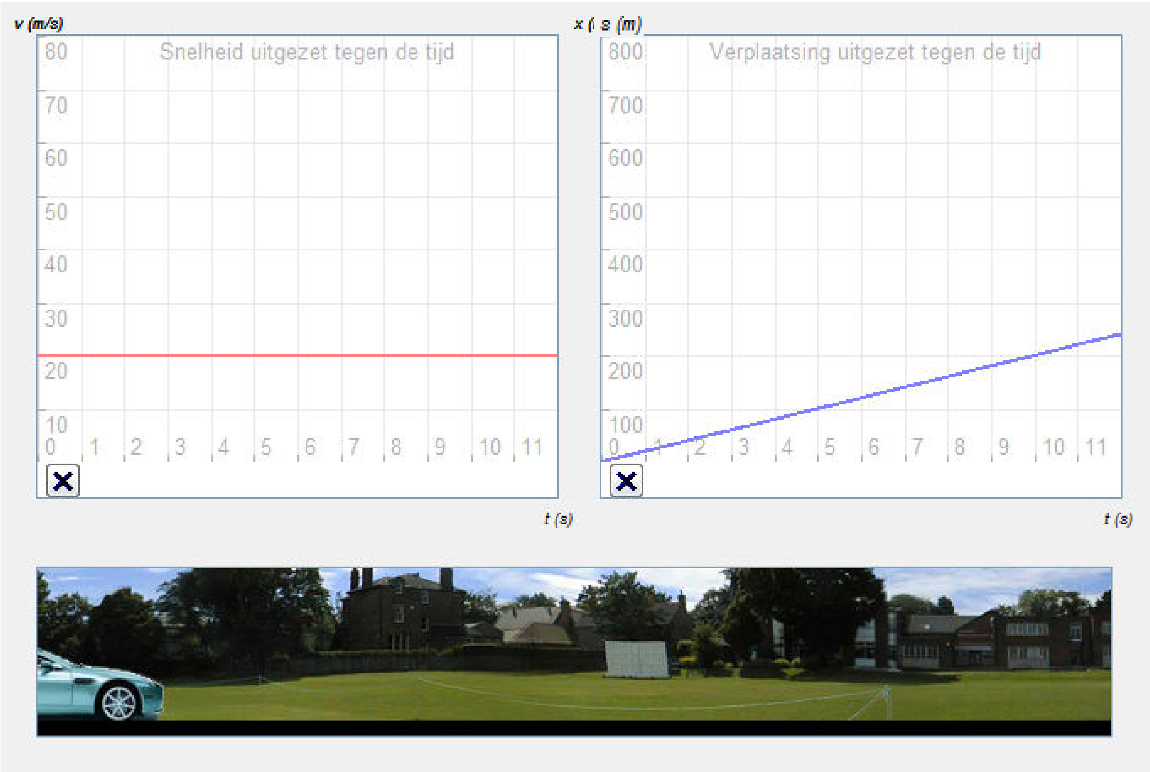
Zimmerman, B. J. (2008). Investigating Self-Regulation and Motivation: Historical Background, Methodological Developments, and Future Prospects. *American Educational Research Journal, 45*(1), 166 –183. doi: 10.3102/0002831207312909

Appendices

Appendix A. *Motivation Questionnaire During Training*

Appendix A1. *Motivation Questionnaire During Training part 1*

Verplaatsing & tijd (opdracht 2-9) **Naam :……………………………………………………………**



Je ziet hierboven een plaatje van de simulatie waarmee je net werkte. Je krijgt straks een aantal vergelijkbare opdrachten. Drie gaan over **verplaatsing**. Dat is de afstand die een auto in een bepaalde tijd aflegt. In de opdrachten moet je bijvoorbeeld de verplaatsing in een tijdsinterval berekenen, of je moet aangeven welke van twee auto's de grootste verplaatsing heeft. Vijf opdrachten gaan over **tijd**. Hierin moet je soms aangeven hoe lang een auto over een bepaald traject doet, of je moet aangeven welke van twee auto's de minste tijd nodig heeft om een bepaalde snelheid te behalen.

Beantwoord nu deze twee vragen voordat je verder gaat. Zet een kruisje op de lijn.

Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

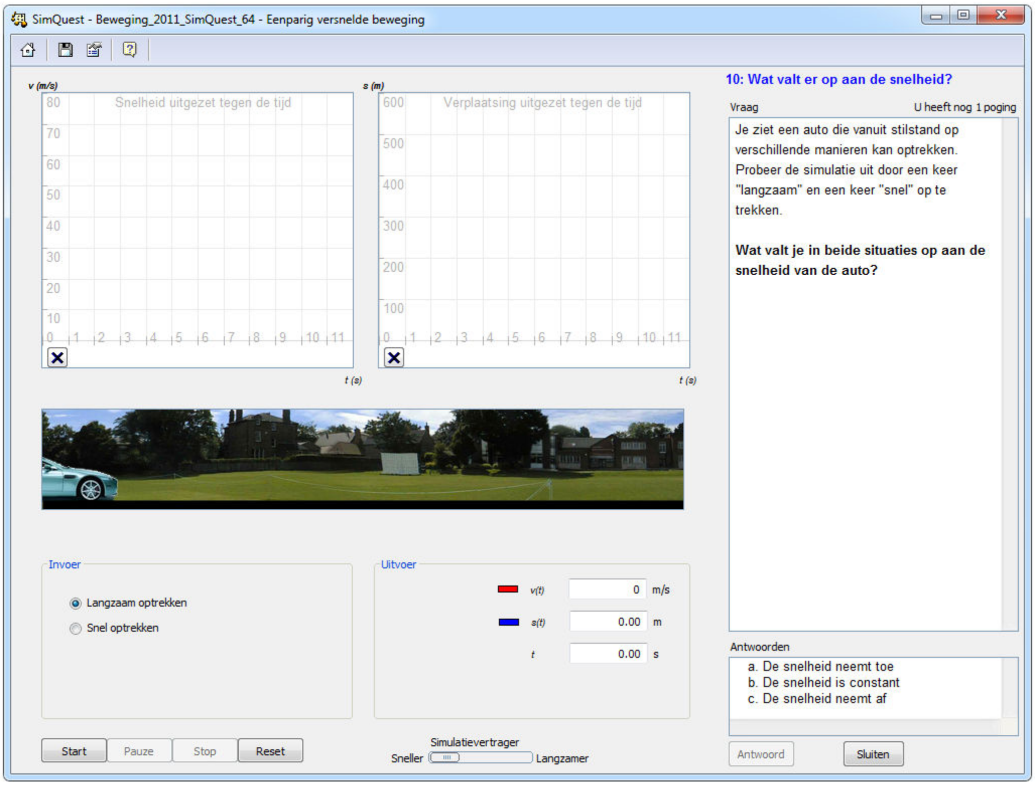
Heel slecht ——————————————— Heel goed

Vraag 2: Hoe relevant vind jij deze onderwerpen?

Helemaal niet relevant ——————————————— Heel relevant

Appendix A2. *Motivation Questionnaire During Training part 2*

Snelheid & snelheidsverandering (opdracht 11-20) **Naam :……………………………………………………………………**



Je ziet hierboven een plaatje van de simulatie waarmee je net werkte. Je krijgt straks een aantal vergelijkbare opdrachten. Zeven opdrachten gaan over **snelheid**. De snelheid geeft aan hoe hard een auto rijdt op een bepaald moment, of gedurende een bepaalde tijdsduur. In de opdrachten moet je bijvoorbeeld voor een bepaald tijdstip aangeven wat de snelheid van een auto is, of welke van twee auto's harder rijdt. Drie opdrachten gaan over **snelheidsverandering**. Dat is het verschil in snelheid tussen het begin en einde van een tijdsinterval. In de opdrachten moet je steeds de toename van de snelheid van een auto berekenen.

Beantwoordt nu deze twee vragen voordat je verder gaat. Zet een kruisje op de lijn.

Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

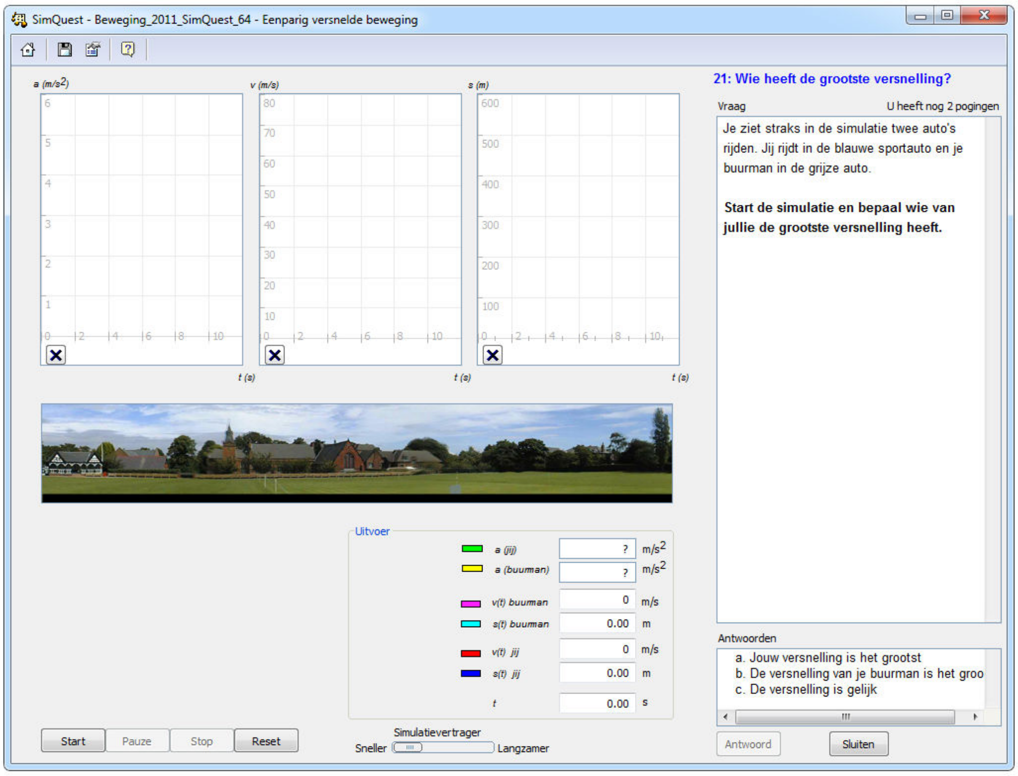
Heel slecht ———————————————— Heel goed

Vraag 2: Hoe relevant vind jij deze onderwerpen?

Helemaal niet relevant ———————————————— Heel relevant

Appendix A3. *Motivation Questionnaire During Training part 3*

Versnelling (opdracht 22 -29) **Naam :………………………………………………………………**



Je ziet hierboven een plaatje van de simulatie waarmee je net werkte. Je krijgt straks acht vergelijkbare opdrachten over **versnelling**. De versnelling is de toename van de snelheid van een auto per seconde. In de opdrachten moet je bijvoorbeeld aangeven bij welke van twee auto's de versnelling het grootst is, of je moet de versnelling van een auto berekenen waarmee deze een bepaalde afstand in een bepaalde tijd kan afleggen.

Beantwoordt nu deze twee vragen voordat je verder gaat. Zet een kruisje op de lijn.

Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

|———————————————————————|

Heel slecht Heel goed

Vraag 2: Hoe relevant vind jij dit onderwerp?

|———————————————————————|

Helemaal niet relevant Heel relevant

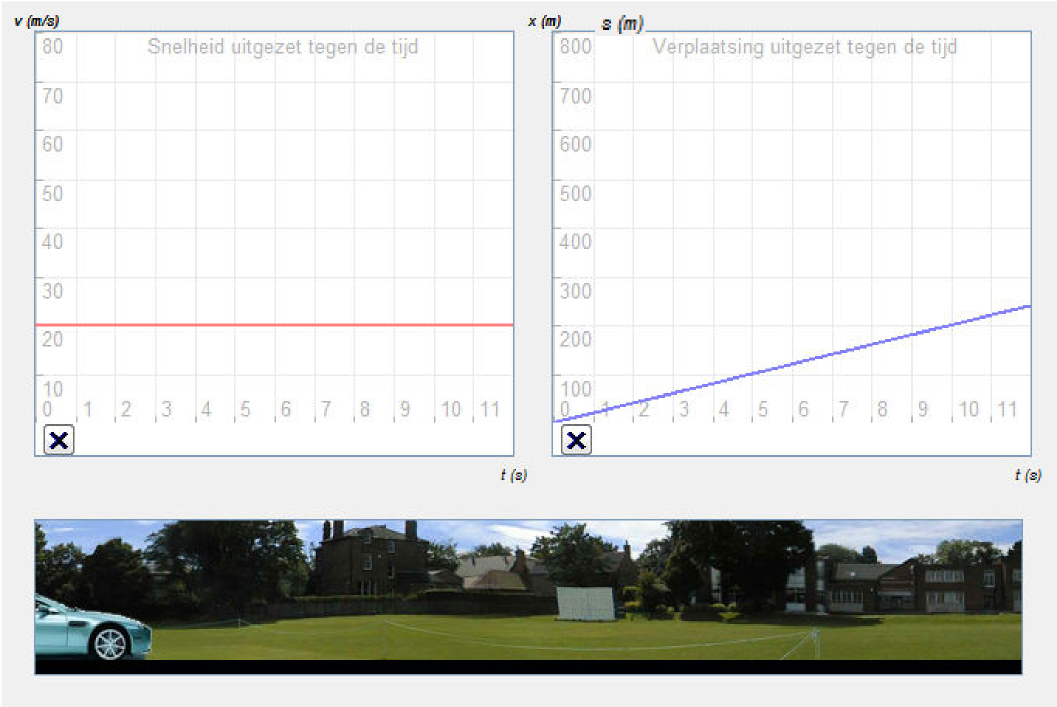
Appendix B. *Motivation Questionnaire After Training*

Naam :……………………………………………………………….

Je hebt zojuist bijna dertig opdrachten gemaakt over het onderwerp eenparig versnelde beweging. Om die opdrachten te kunnen maken heb je gebruik gemaakt van simulaties. De opdrachten waren gegroepeerd in ‘’verplaatsing & tijd”, “snelheid & snelheidsverandering”, en “versnelling”. We hebben je na de eerste opdracht uit zo’n groep steeds twee vragen gesteld.

Je krijgt nu nogmaals dezelfde vragen over elke groep. We vragen je je daarbij voor te stellen dat je weer met de simulatie gaat werken aan vergelijkbare, nieuwe opdrachten.

Verplaatsing & tijd **Naam :………………………………………………………………**



Stel je voor dat straks weer een aantal vergelijkbare opdrachten krijgt over verplaatsing en tijd. Drie opdrachten gaan over **verplaatsing**. Dat is de afstand die een auto in een bepaalde tijd aflegt. In de opdrachten moet je bijvoorbeeld de verplaatsing in een tijdsinterval berekenen, of je moet aangeven welke van twee auto's de grootste verplaatsing heeft. Vijf opdrachten gaan over **tijd**. Hierin moet je soms aangeven hoe lang een auto over een bepaald traject doet, of je moet aangeven welke van twee auto's de minste tijd nodig heeft om een bepaalde snelheid te behalen.

Beantwoord nu deze twee vragen. Zet een kruisje op de lijn.

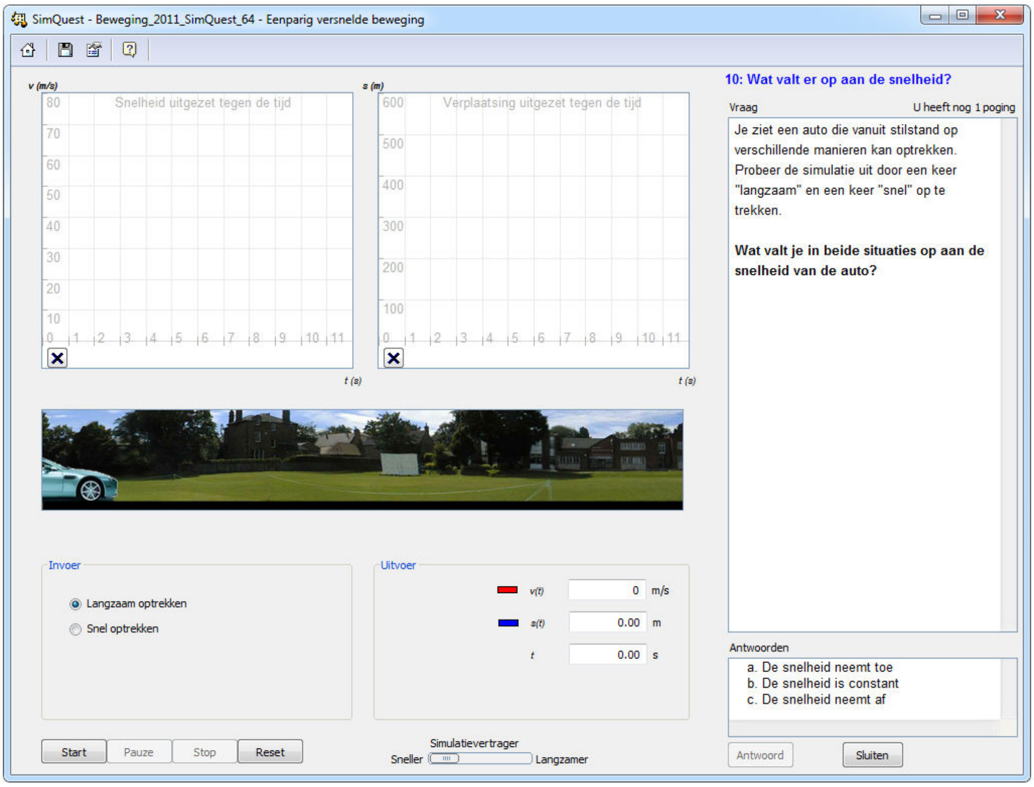
Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

Heel slecht ———————————————— Heel goed

Vraag 2: Hoe relevant vind jij deze onderwerpen?

Helemaal niet relevant ———————————————— Heel relevant

Snelheid & snelheidsverandering **Naam :………………………………………………………………**



Stel je voor dat straks weer een aantal vergelijkbare opdrachten krijgt over snelheid en snelheidsverandering. Zeven opdrachten gaan over **snelheid**. De snelheid geeft aan hoe hard een auto rijdt op een bepaald moment, of gedurende een bepaalde tijdsduur. In de opdrachten moet je bijvoorbeeld voor een bepaald tijdstip aangeven wat de snelheid van een auto is, of welke van twee auto's harder rijdt. Drie opdrachten gaan over **snelheidsverandering**. Dat is het verschil in snelheid tussen het begin en einde van een tijdsinterval. In de opdrachten moet je steeds de toename van de snelheid van een auto berekenen.

Beantwoord nu deze twee vragen. Zet een kruisje op de lijn.

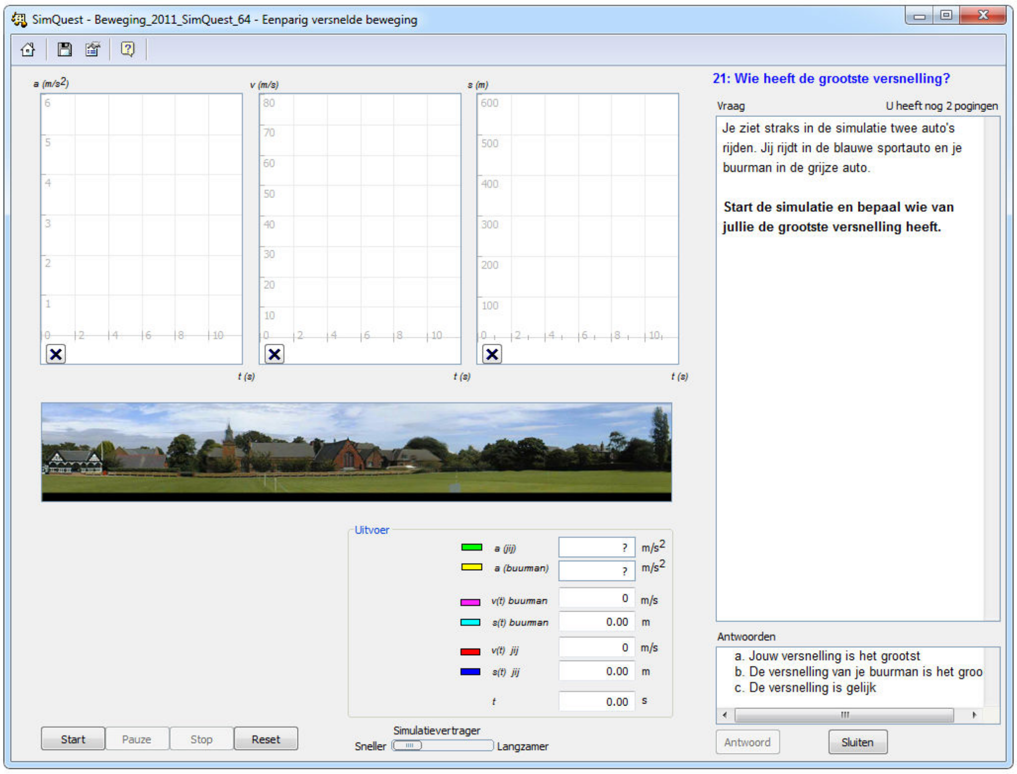
Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

Heel slecht ———————————————— Heel goed

Vraag 2: Hoe relevant vind jij deze onderwerpen?

Helemaal niet relevant ———————————————— Heel relevant

Versnelling **Naam :……………………………………………………………………**



Stel je voor dat straks weer acht vergelijkbare opdrachten krijgt over **versnelling**. De versnelling is de toename van de snelheid van een auto per seconde. In de opdrachten moet je bijvoorbeeld aangeven bij welke van twee auto's de versnelling het grootst is, of je moet de versnelling van een auto berekenen waarmee deze een bepaalde afstand in een bepaalde tijd kan afleggen.

Beantwoord nu deze twee vragen. Zet een kruisje op de lijn.

Vraag 1: Hoe goed denk je dat je deze opdrachten gaat maken?

Heel slecht Heel goed

Vraag 2: Hoe relevant vind jij dit onderwerp?

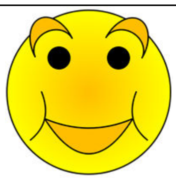
Helemaal niet relevant Heel relevant

Appendix C. *Mood and Cognitive Load Questionnaire*

Naam :………………………………………………………………

Beantwoord deze twee vragen.

Vraag 1: Hoe voel jij je na deze taak?

				
Blij	**Zeker**	**Neutraal**	**Onzeker**	**Verdrietig**

Vraag 2: Hoe moeilijk vond jij deze taak?
Zet een kruisje op de lijn.

Heel moeilijk Heel makkelijk

Appendix D. *Agent Questionnaire*

Naam: ……………………………………………………………………………….

In de simulatie gaf Emma steeds commentaar.

Kun je aangeven wat je van dat commentaar vond?

Zet bij elke vraag een kruisje.

	Klopt niet — **Klopt wel**
1. Ik kon me Emma's commentaar goed voorstellen.	
2. Emma stimuleerde me om door te gaan.	
3. Ik was benieuwd hoe Emma zou reageren.	
4. Ik vond het commentaar nuttig.	
5. Ik voelde me net zoals Emma.	
6. Ik vond het commentaar leuk.	
7. Emma deed me wel wat.	
8. Emma zei wat ik ook dacht.	
9. Emma gaf weinig informatie.	
10. Ik vond het commentaar stom.	
11. Als het voor Emma moeilijk was, vond ik het ook moeilijk.	

Appendix E. *Knowledge Pre-test*

Toetsvragen
'Beweging'

Naam: ………………………………………………………………………………………………

Leeftijd: ...……………………………………………………………………………………….

Geslacht*: M / V

Klas: ……………………………………………………………………………………………..

**Doorhalen wat niet van toepassing is*

INSTRUCTIE

Je krijgt straks een aantal vragen over het onderwerp 'beweging'. Een aantal vragen kan gaan over lesstof die je nog niet hebt gehad. Probeer toch op alle vragen een antwoord te geven. We willen namelijk weten wat je *op dit moment* allemaal al over het onderwerp 'beweging' weet.

Hieronder staat een voorbeeldvraag. Deze geeft aan hoe je de vragen straks moet gaan beantwoorden.

Voorbeeld:

Vraag 1. In welke maand begint de lente?

☐ januari

***Let op*: Heb je het verkeerde antwoord aangekruist?**

Kleur dan het vakje voor het verkeerde antwoord helemaal in en kruis opnieuw het vakje voor het juiste antwoord aan. Zie hieronder.

Voorbeeld:

Vraag 1. In welke maand begint de lente?

☐ januari

☐ februari

Je kunt nu beginnen met het beantwoorden van de vragen.
SUCCES!

Vraag 1. **De oppervlakte onder het (*a,t*)-diagram geeft:**

- ☐ de snelheid
- ☐ de snelheidsverandering
- ☐ de verplaatsing
- ☐ de versnelling

Vraag 2. **Wat is de eenheid van versnelling?**

- ☐ a
- ☐ m
- ☐ m/s
- ☐ m/s^2

Vraag 3. **Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?**

I. **De vertraging is de snelheidsverandering gedeeld door de benodigde tijd.**

II. **De gemiddelde snelheid bij een eenparig rechtlijnige beweging is de verplaatsing gedeeld door de benodigde tijd.**

- ☐ Beide stellingen zijn juist.
- ☐ Stelling I is juist, stelling II is onjuist.
- ☐ Stelling I is onjuist, stelling II is juist.
- ☐ Beide stellingen zijn onjuist.

Vraag 4. **De oppervlakte onder het (*v,t*)-diagram geeft:**

- ☐ de snelheid
- ☐ de verplaatsing
- ☐ de versnelling
- ☐ geen van bovenstaande antwoorden

Vraag 5. Wat is de formule voor het berekenen van de verplaatsing bij een eenparig rechtlijnige beweging?

☐ $x(t) = \triangle v \cdot a$

☐ $x(t) = v_{gem} \cdot t^2$

☐ $x(t) = v \cdot t$

☐ $x(t) = ½ \cdot a \cdot t^2$

Vraag 6. Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?

I. Bij een eenparig rechtlijnige beweging is de grafiek in het (*x,t*)-diagram een rechte lijn evenwijdig aan de tijdas.

II. Bij een eenparig versnelde beweging vanuit stilstand is de grafiek in het (*x,t*)-diagram een schuin oplopende rechte lijn die in de oorsprong begint.

☐ Beide stellingen zijn juist.

☐ Stelling I is juist, stelling II is onjuist.

☐ Stelling I is onjuist, stelling II is juist.

☐ Beide stellingen zijn onjuist.

Vraag 7. Wat geeft de steilheid van de grafiek in het (*v,t*)-diagram weer?

☐ de snelheid

☐ de snelheidsverandering

☐ de verplaatsing

☐ de versnelling

Vraag 8. Wat is de formule voor het berekenen van de snelheid op tijdstip *t* bij een eenparig versnelde beweging vanuit stilstand?

☐ $v(t) = \triangle x \cdot a$

☐ $v(t) = x \cdot t^2$

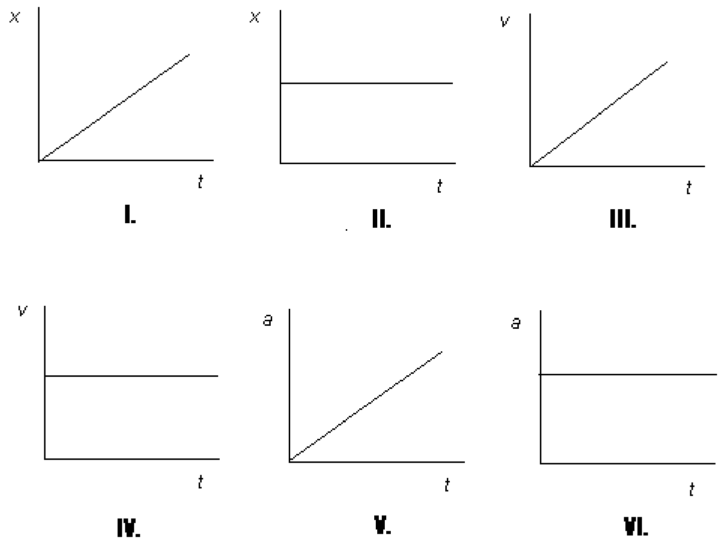
☐ $v(t) = a \cdot t$

☐ $v(t) = ½ \cdot a \cdot t^2$

Vraag 9. Wat geeft de steilheid van de grafiek in het (*x,t*)-diagram weer?

- ☐ de snelheid
- ☐ de versnelling
- ☐ de verplaatsing
- ☐ geen van bovenstaande antwoorden

Vraag 10. Hieronder staan een aantal diagrammen. Welk(e) diagram(men) past/passen bij een eenparig versnelde beweging?



- ☐ Alleen diagram II
- ☐ Diagram I, III en VI
- ☐ Diagram I, IV en V
- ☐ Diagram III en VI

Vraag 11. **Een automonteur onderzoekt de versnelling van drie verschillende auto's en vindt de volgende resultaten:**

- **de snelheid van auto A verandert in 1 seconde van 1 m/s naar 2 m/s.**
- **de snelheid van auto B verandert van 1 m/s naar 3 m/s in 2 seconden.**
- **de snelheid van auto C verandert in 5 seconden van 1 m/s naar 5 m/s.**

Welk van de antwoorden geeft de relatie tussen de versnelling van de drie verschillende auto's het beste weer?

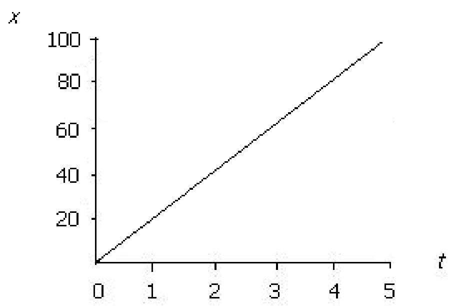
☐ de versnelling van auto A = de versnelling van auto B = de versnelling van auto C

☐ de versnelling van auto A > de versnelling van auto B > de versnelling van auto C

☐ de versnelling van auto A < de versnelling van auto B < de versnelling van auto C

☐ de versnelling van auto A = de versnelling van auto B > de versnelling van auto C

Vraag 12. **Jan en Anna bestuderen het onderstaande (*x,t*)-diagram van een auto:**



Jan beweert dat hij aan de hand van het (*x,t*)-diagram de snelheid van de auto op tijdstip *t* = 2 kan berekenen.

Volgens Anna heb kun je uit het (*x,t*)-diagram afleiden of de auto een versnelling ondergaat.

Wie heeft er gelijk?

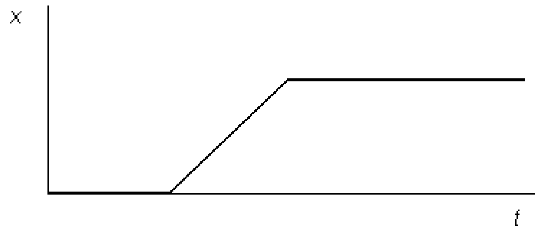
☐ Zowel Jan als Anna

☐ Jan

☐ Anna

☐ Geen van beiden

Vraag 13. Hieronder staat het (*x,t*)-diagram van een balletje. Welke van de onderstaande uitspraken is een juiste interpretatie van het diagram?



- ☐ Het balletje rolt eerst met een constante snelheid, meerdert dan vaart en blijft vervolgens doorrollen met een constante snelheid.
- ☐ Het balletje rolt over een vlak oppervlak, rolt vervolgens een heuvel op en blijft dan doorrollen.
- ☐ Het balletje beweegt eerst niet, rolt vervolgens weg en stopt uiteindelijk.
- ☐ Het balletje rolt over een vlak oppervlak, rolt vervolgens een heuvel op en stopt uiteindelijk.

Vraag 14. Hoe haal je de plaats op een bepaald tijdstip uit het (*x,t*)-diagram?

- ☐ Door de waarde die hoort bij dat tijdstip af te lezen.
- ☐ Door de oppervlakte onder de grafiek te bepalen van tijdstip 0 tot dat tijdstip.
- ☐ Door de steilheid van de grafiek te bepalen.
- ☐ Door de snelheid te bepalen en te delen door dat tijdstip.

Vraag 15. Hoe haal je de versnelling op een bepaald tijdstip uit het (*a,t*)-diagram?

- ☐ Door de waarde die hoort bij dat tijdstip af te lezen.
- ☐ Door de oppervlakte onder de grafiek te bepalen van tijdstip 0 tot dat tijdstip.
- ☐ Door de steilheid van de grafiek op dat tijdstip te bepalen.
- ☐ Door de snelheidsverandering te bepalen en te delen door de benodigde tijd van tijdstip 0 tot dat tijdstip.

Vraag 16. Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?

I. Als een bewegend voorwerp een versnelling ondergaat, dan zal de snelheid van het voorwerp toenemen met de tijd.

II. Als een bewegend voorwerp een versnelling ondergaat, dan zal de afstand die het voorwerp per seconde aflegt steeds gelijk blijven.

☐ Beide stellingen zijn juist.

☐ Stelling I is juist, stelling II is onjuist.

☐ Stelling I is onjuist, stelling II is juist.

☐ Beide stellingen zijn onjuist.

Vraag 17. Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?

I. Als een bewegend voorwerp geen versnelling ondergaat, dan zal de afstand die het voorwerp per seconde aflegt steeds met dezelfde waarde toenemen.

II. Als de versnelling van een bewegend voorwerp gelijk is aan nul, dan zal de snelheid van het voorwerp constant blijven.

☐ Beide stellingen zijn juist.

☐ Stelling I is juist, stelling II is onjuist.

☐ Stelling I is onjuist, stelling II is juist.

☐ Beide stellingen zijn onjuist.

Vraag 18. Je kunt de verplaatsing tussen tijdstip 0 en tijdstip *t* uit het (*v,t*)-diagram halen door:

☐ de juiste waarde af te lezen op tijdstip *t*.

☐ de oppervlakte onder de grafiek van tijdstip 0 tot tijdstip *t* te bepalen.

☐ de steilheid van de grafiek tussen tijdstip 0 en tijdstip *t* te bepalen.

☐ Je kunt de verplaatsing niet uit het (*v,t*)-diagram halen.

Vraag 19. Welke van de onderstaande begrippen is het <u>sterkst</u> verbonden met het begrip *snelheid* wanneer er sprake is van een eenparig versnelde beweging?

☐ Snelheidsverandering

☐ Verplaatsing

☐ Versnelling

☐ Geen van bovenstaande begrippen

Vraag 20. **Welk van de onderstaande begrippen is het <u>minst sterk</u> verbonden met het begrip *snelheidsverandering*?**

- ☐ Tijd
- ☐ Verplaatsing
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Vraag 21. **Hieronder staan een aantal begrippen die betrekking hebben op het onderwerp beweging. Welke van de onderstaande begrippen is het <u>minst sterk</u> verbonden met het begrip *tijd*?**

- ☐ Snelheid
- ☐ Snelheidsverandering
- ☐ Verplaatsing
- ☐ Geen van bovenstaande begrippen

Vraag 22. **Wat is een juiste opsomming van begrippen die een rol spelen binnen eenparig rechtlijnige bewegingen?**

- ☐ Tijd, snelheid, verplaatsing
- ☐ Tijd, snelheidsverandering, versnelling
- ☐ Snelheid, verplaatsing, versnelling
- ☐ Snelheid, snelheidsverandering, verplaatsing

Vraag 23. **Welke van de onderstaande begrippen is het <u>sterkst</u> verbonden met het begrip *verplaatsing* wanneer er sprake is van een eenparig rechtlijnige beweging?**

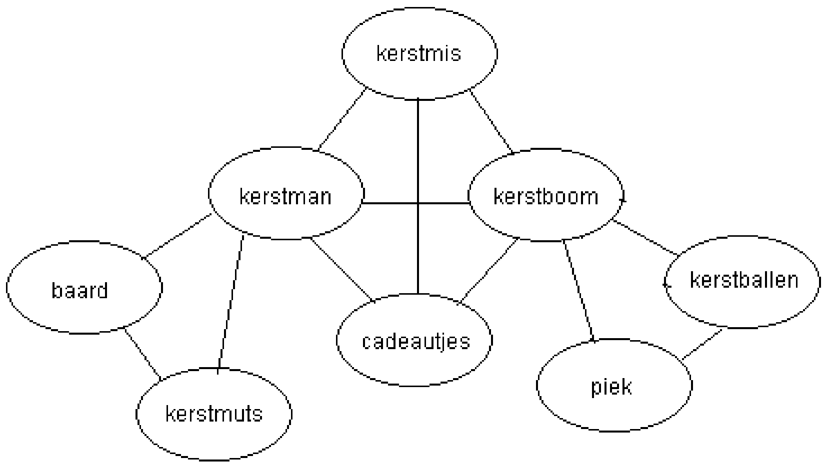
- ☐ Snelheid
- ☐ Snelheidsverandering
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Vraag 24. **Welke van de onderstaande begrippen zijn kenmerkend voor eenparig versnelde bewegingen, maar niet voor eenparig rechtlijnige bewegingen?**

- ☐ Tijd en versnelling
- ☐ Snelheidsverandering en verplaatsing
- ☐ Versnelling en snelheidsverandering
- ☐ Verplaatsing en snelheid

Je krijgt nu enkele vragen over concept maps. Een **concept map** is een afbeelding van **begrippen** en hun onderlinge **verbanden**.

Hieronder staat een voorbeeld van een concept map over het onderwerp 'kerstmis'. In de ovalen staan de begrippen. De lijnen tussen de ovalen geven aan dat er een verband is tussen de begrippen. Je ziet dat de begrippen *kerstman* en *kerstmuts* direct verbonden zijn. Je kunt ook zien dat het begrip *kerstman* indirect verbonden is met het begrip *kerstballen*. Het verband tussen *kerstman* en *kerstballen* is dus minder sterk dan tussen *kerstman* en *kerstmuts*.

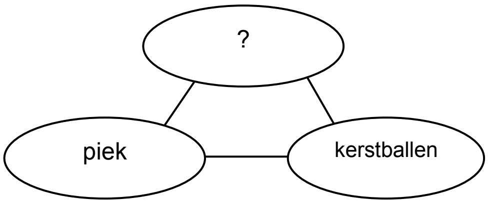


Figuur 1. Een concept map over het onderwerp 'kerstmis'.

In de vragen die je straks krijgt is een begrip vervangen door een vraagteken. Jij moet dan aangeven welk
begrip het beste op de plek van het vraagteken past.

Voorbeeld

Vraag 1a) Hieronder staat een concept map over het onderwerp 'kerstmis'. Welk begrip past het <u>beste</u> op de plek van het vraagteken?

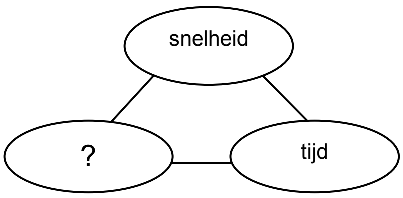


☐ Kerstman
☒ Kerstboom
☐ Cadeautjes
☐ Kerstmuts

<u>Uitleg voorbeeldvraag:</u>
Het goede antwoord is *kerstboom*, omdat er een <u>direct</u> verband tussen deze drie begrippen is.

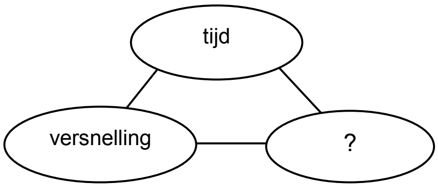
Je kunt nu verder gaan met het beantwoorden van de vragen over concept maps.

Vraag 25. Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welk begrip past het <u>beste</u> op de plek van het vraagteken?



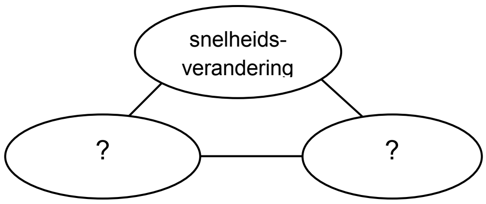
☐ Snelheidsverandering
☐ Verplaatsing
☐ Versnelling
☐ Geen van bovenstaande begrippen

Vraag 26. **Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welk begrip past het <u>minst</u> op de plek van het vraagteken?**



- ☐ Snelheid
- ☐ Snelheidsverandering
- ☐ Verplaatsing
- ☐ Geen van bovenstaande begrippen

Vraag 27. **Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welke begrippen passen het <u>beste</u> op de plek van de vraagtekens?**



- ☐ Snelheid en verplaatsing
- ☐ Tijd en snelheid
- ☐ Verplaatsing en versnelling
- ☐ Versnelling en tijd

Appendix F. *Knowledge Post-test*

Toetsvragen
‘Beweging’

Naam: ……………………………………………………………………………………………

Leeftijd: ……………………………………………………………………………………………..

Geslacht*: M / V

Klas: ……………………………………………………………………………………………..

**Doorhalen wat niet van toepassing is*

INSTRUCTIE

Je krijgt straks een aantal vragen over het onderwerp 'beweging'.
Hieronder staat een voorbeeldvraag. Deze geeft aan hoe je de vragen straks moet gaan beantwoorden.

Voorbeeld:

Vraag 1. In welke maand begint de lente?

☐ januari

***Let op*: Heb je het verkeerde antwoord aangekruist?**

Kleur dan het vakje voor het verkeerde antwoord helemaal in en kruis opnieuw het vakje voor het juiste antwoord aan. Zie hieronder.

Voorbeeld:

Vraag 1. In welke maand begint de lente?

☐ januari

☐ februari

Je kunt nu beginnen met het beantwoorden van de vragen.
SUCCES!

Vraag 1. **Wat is de formule voor het berekenen van de verplaatsing bij een eenparig versnelde beweging?**

- ☐ $x(t) = \triangle v \cdot a$
- ☐ $x(t) = v_{gem} \cdot t^2$
- ☐ $x(t) = v \cdot t$
- ☐ $x(t) = ½ \cdot a \cdot t^2$

Vraag 2. **De verplaatsing is gelijk aan de oppervlakte onder de grafiek van het:**

- ☐ (x,t)-diagram
- ☐ (v,t)-diagram
- ☐ (a,t)-diagram
- ☐ geen van bovenstaande diagrammen

Vraag 3. **Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?**

I. **Bij een eenparig versnelde beweging is de grafiek in het (*v,t*)-diagram een stukje parabool.**

II. **Bij een eenparig rechtlijnige beweging is de grafiek in het (*x,t*)-diagram een rechte lijn die evenwijdig loopt aan de tijdas.**

- ☐ Beide stellingen zijn juist.
- ☐ Stelling I is juist, stelling II is onjuist.
- ☐ Stelling I is onjuist, stelling II is juist.
- ☐ Beide stellingen zijn onjuist.

Vraag 4. **Wat is de formule voor het berekenen van de gemiddelde snelheid in een tijdsinterval bij een eenparig versnelde beweging?**

☐ $v(t) = a \cdot t$

☐ $\Delta v = \frac{a}{\Delta t}$

☐ $v_{gem} = \frac{\Delta x}{\Delta t}$

☐ $v_{gem} = \frac{v_{begin} + v_{eind}}{2}$

Vraag 5. **De snelheid is gelijk aan de oppervlakte onder de grafiek van het:**

☐ (*x*,*t*)-diagram
☐ (*v*,*t*)-diagram
☐ (*a*,*t*)-diagram
☐ geen van bovenstaande diagrammen

Vraag 6. **De steilheid van de grafiek in het (*x*,*t*)-diagram is gelijk aan:**

☐ de snelheid
☐ de verplaatsing
☐ de versnelling
☐ geen van bovenstaande antwoorden

Vraag 7. **Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?**

III. **De snelheidsverandering in een tijdsinterval bepaal je door de snelheid aan het begin van het tijdsinterval af te trekken van de snelheid aan het eind van het tijdsinterval.**

IV. **De verplaatsing bij een eenparig rechtlijnige beweging bepaal je door de snelheid te delen door de benodigde tijd.**

☐ Beide stellingen zijn juist.
☐ Stelling I is juist, stelling II is onjuist.
☐ Stelling I is onjuist, stelling II is juist.
☐ Beide stellingen zijn onjuist.

Vraag 8. Wat is het symbool voor versnelling?

- ☐ a
- ☐ m
- ☐ m/s
- ☐ m/s^2

Vraag 9. De steilheid van de grafiek in het (*v,t*)-diagram is gelijk aan:

- ☐ de snelheid
- ☐ de verplaatsing
- ☐ de versnelling
- ☐ geen van bovenstaande antwoorden

Vraag 10. De versnelling op een bepaald tijdstip haal je uit het (*a,t*)-diagram door:

- ☐ de oppervlakte onder de grafiek te bepalen van tijdstip 0 tot dat tijdstip.
- ☐ de waarde die hoort bij dat tijdstip af te lezen.
- ☐ de snelheidsverandering te bepalen en te delen door de benodigde tijd van tijdstip 0 tot dat tijdstip.
- ☐ de steilheid van de grafiek op dat tijdstip te bepalen.

Vraag 11. Hoe haal je de verplaatsing uit het (*v,t*)-diagram?

- ☐ Door de steilheid van de grafiek te bepalen.
- ☐ Door de juiste waarde af te lezen.
- ☐ Door de oppervlakte onder de grafiek te bepalen.
- ☐ Je kunt de verplaatsing niet uit het (*v,t*)-diagram halen.

Vraag 12. Pieter, Maartje, Anna en Pim hebben tijdens een practicumles de volgende gegevens over twee scooters verzameld:

- **de snelheid van scooter 1 verandert in 1 seconde van 3 m/s naar 4 m/s.**
- **de snelheid van scooter 2 verandert in 2 seconden van 4 m/s naar 6 m/s.**

- **Pieter beweert dat de versnelling van scooter 1 groter is dan de versnelling van scooter 2.**
- **Maartje beweert dat de versnelling van beide scooters gelijk is.**
- **Anna beweert dat de versnelling van scooter 2 groter is dan de versnelling van scooter 1.**
- **Pim beweert dat ze geen uitspraken kunnen doen over de versnelling van de scooters omdat ze hiervoor te weinig gegevens hebben.**

Wie heeft er gelijk?

☐ Pieter

☐ Maartje

☐ Anna

☐ Pim

Vraag 13. De plaats op tijdstip *t* haal je uit het (*x,t*)-diagram door:

☐ de steilheid van de grafiek te bepalen.

☐ de snelheid te bepalen en te delen door dat tijdstip.

☐ de oppervlakte onder de grafiek te bepalen van tijdstip 0 tot dat tijdstip.

☐ de waarde die hoort bij dat tijdstip af te lezen.

Vraag 14. Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?

III. Als een bewegend voorwerp een versnelling ondergaat, dan zal de snelheid van het voorwerp op ieder tijdstip gelijk zijn.

IV. Als een bewegend voorwerp geen versnelling ondergaat, dan zal de afstand die het voorwerp per seconde aflegt steeds gelijk blijven.

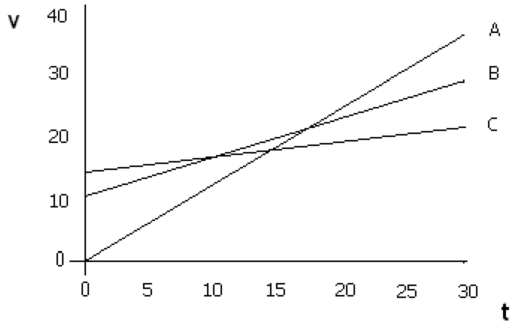
☐ Beide stellingen zijn juist.

☐ Stelling I is juist, stelling II is onjuist.

☐ Stelling I is onjuist, stelling II is juist.

☐ Beide stellingen zijn onjuist.

Vraag 15. **Hieronder staat het (*v,t*)-diagram van auto A, B en C. Welke van de onderstaande uitspraken is juist?**



☐ Auto C rijdt op tijdstip *t* = 5 het snelst.

☐ Op tijdstip *t* = 10 rijdt auto B 10 m/s harder dan op tijdstip *t* = 0.

☐ Over de snelheid van auto A op tijdtip *t* = 20 is niets bekend.

☐ Op tijdstip *t* = 15 rijden auto B en auto C even snel.

Vraag 16. **Hieronder staan twee stellingen. Wat kan er over deze stellingen gezegd worden?**

III. **Als een bewegend voorwerp een versnelling ondergaat, dan zal de afstand die het voorwerp per seconde aflegt steeds groter worden.**

IV. **Als een bewegend voorwerp een versnelling ondergaat, dan zal de snelheid van het voorwerp iedere seconde toenemen.**

☐ Beide stellingen zijn juist.

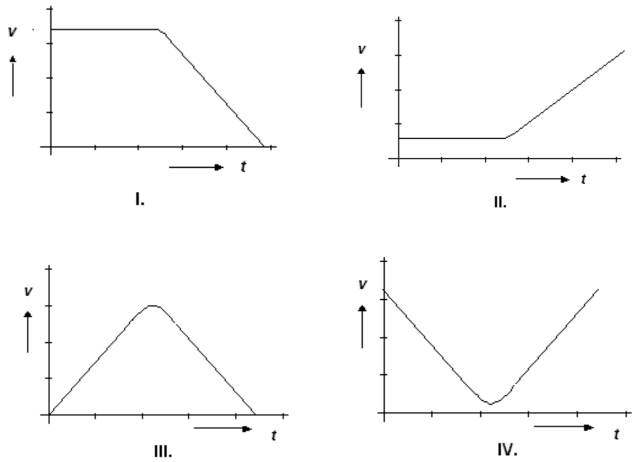
☐ Stelling I is juist, stelling II is onjuist.

☐ Stelling I is onjuist, stelling II is juist.

☐ Beide stellingen zijn onjuist.

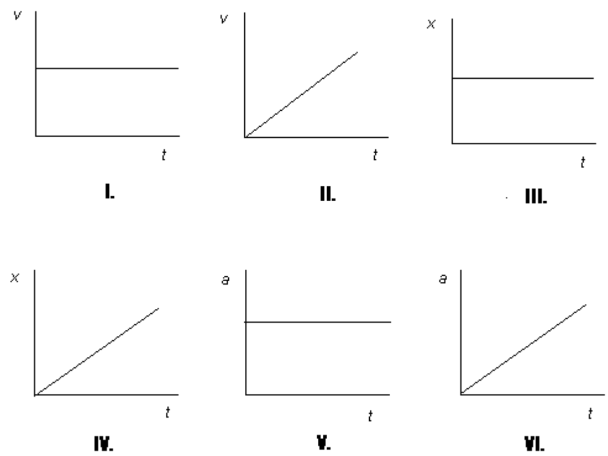
Vraag 17. **Hieronder staan 4 (*v,t*)-diagrammen van achtbaanwagentjes. Welk diagram pas het beste bij onderstaande situatie?**

De achtbaanwagentjes worden vanaf de start met constant motorvermogen omhoog getrokken naar het hoogste punt van de achtbaan. Vanaf dat punt bewegen de wagentjes uit zichzelf naar beneden.



- ☐ Diagram I
- ☐ Diagram II
- ☐ Diagram III
- ☐ Diagram IV

Vraag 18. **Hieronder staan een aantal diagrammen. Welk(e) diagram(men) past/passen bij een beweging met een constante versnelling groter dan nul?**



- ☐ Alleen diagram II
- ☐ Diagram I, III en VI
- ☐ Diagram II en V
- ☐ Diagram II, IV en V

Vraag 19. Welke van de onderstaande begrippen spelen een rol binnen eenparig rechtlijnige bewegingen?

- ☐ Tijd, snelheid, verplaatsing
- ☐ Tijd, snelheidsverandering, versnelling
- ☐ Snelheid, verplaatsing, versnelling
- ☐ Snelheid, snelheidsverandering, verplaatsing

Vraag 20. Welk van de onderstaande begrippen is het minst sterk verbonden met het begrip *verplaatsing* wanneer er sprake is van een eenparig versnelde beweging?

- ☐ Snelheidsverandering
- ☐ Tijd
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Vraag 21. Welk van de onderstaande begrippen hoort niet in het rijtje thuis wanneer er sprake is van een eenparig versnelde beweging?

- ☐ Snelheid
- ☐ Snelheidsverandering
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Vraag 22. Welk van de onderstaande begrippen is het sterkst verbonden met het begrip *tijd* wanneer er sprake is van een eenparig rechtlijnige beweging?

- ☐ Snelheid
- ☐ Snelheidsverandering
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Vraag 23. Welke van de onderstaande opsomming van begrippen is *alleen* kenmerkend voor eenparig versnelde bewegingen, en dus niet voor eenparig rechtlijnige bewegingen?

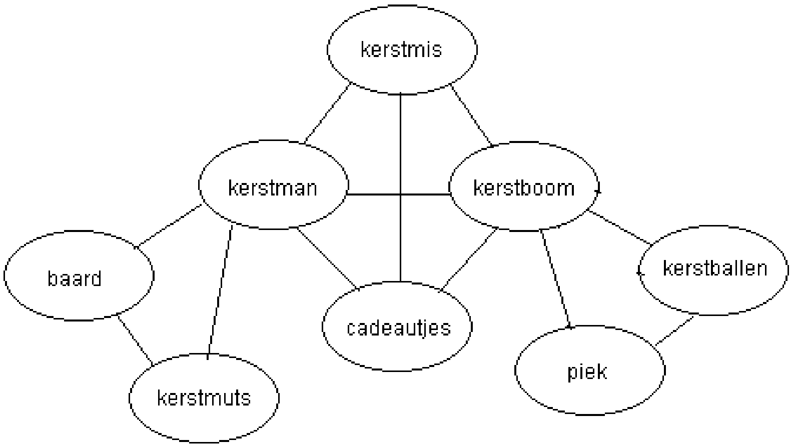
- ☐ Snelheid en verplaatsing
- ☐ Snelheidsverandering en versnelling
- ☐ Versnelling en tijd
- ☐ Tijd en snelheidsverandering

Vraag 24. Welk van de onderstaande begrippen is het minst sterk verbonden met het begrip *snelheid* wanneer er sprake is van een eenparig versnelde beweging?

- ☐ Tijd
- ☐ Verplaatsing
- ☐ Versnelling
- ☐ Geen van bovenstaande begrippen

Je krijgt nu enkele vragen over concept maps. Een **concept map** is een afbeelding van **begrippen** en hun onderlinge **verbanden**.

Hieronder staat een voorbeeld van een concept map over het onderwerp 'kerstmis'. In de ovalen staan de begrippen. De lijnen tussen de ovalen geven aan dat er een verband is tussen de begrippen. Je ziet dat de begrippen *kerstman* en *kerstmuts* direct verbonden zijn. Je kunt ook zien dat het begrip *kerstman* indirect verbonden is met het begrip *kerstballen*. Het verband tussen *kerstman* en *kerstballen* is dus minder sterk dan tussen *kerstman* en *kerstmuts*.

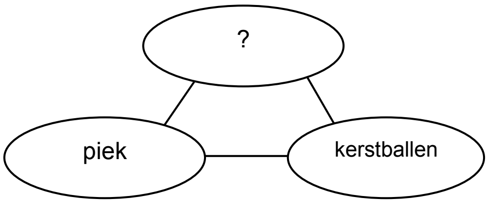


Figuur 1. Een concept map over het onderwerp 'kerstmis'.

In de vragen die je straks krijgt is een begrip vervangen door een vraagteken. Jij moet dan aangeven welk begrip het beste op de plek van het vraagteken past. Op de volgende bladzijde staat een voorbeeldvraag.

Voorbeeld

Vraag **Hieronder staat een concept map over het onderwerp 'kerstmis'. Welk begrip past het <u>beste</u> op de plek van het vraagteken?**

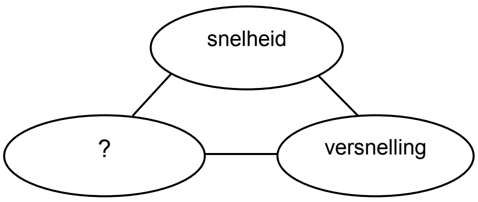


☐ Kerstman
☒ Kerstboom
☐ Cadeautjes
☐ Kerstmuts

Uitleg voorbeeldvraag:
Het goede antwoord is *kerstboom*, omdat er een direct verband tussen deze drie begrippen is.

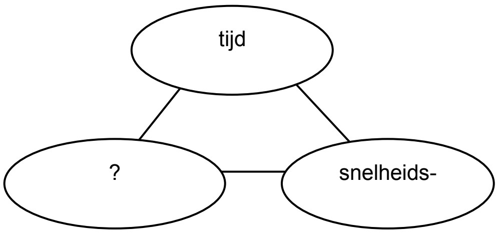
Je kunt nu verder gaan met het beantwoorden van de vragen over concept maps.

Vraag 25. **Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welk begrip past het beste op de plek van het vraagteken?**



☐ Snelheidsverandering
☐ Tijd
☐ Verplaatsing
☐ Geen van bovenstaande begrippen

Vraag 26. Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welk begrip past het <u>beste</u> op de plek van het vraagteken?



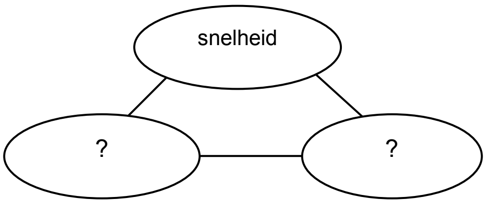
☐ Snelheid

☐ Verplaatsing

☐ Versnelling

☐ Geen van bovenstaande begrippen

Vraag 27. Hieronder staat een concept map over het onderwerp *eenparig versnelde beweging*. Welke begrippen passen het <u>beste</u> op de plek van de vraagtekens?



☐ Snelheidsverandering en versnelling

☐ Tijd en verplaatsing

☐ Verplaatsing en versnelling

☐ Geen van bovenstaande combinatie van begrippen