Colour-signalling in Online Inquiry-based Learning Environments

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Abstract

The aim of the present study was to investigate the relation between prior knowledge, reading skills, motivation to read, and personal interest in science & technology with the information integration between text and pictures and to investigate whether motivation to read has a moderation effect on the relation between reading skills and information integration. Participants were second level students in lower vocational training (N = 71). Their information integration was measured after these students encountered a colour-signal that highlighted relating parts of text and pictures in an online inquiry-based learning (IBL) environment. The information integration was operated as the change in number of switching eye-movements students made between text and pictures right before and right after the colour-signal. The eye-movements were gathered with an eye-tracker while students made a science lesson in the online IBL environment.

Results showed no relation between the individual characteristics and information integration, except for a relation between prior knowledge and information integration. Furthermore, motivation to read had no moderation effect on the relation between reading skills and the information integration. To conclude, the level of prior knowledge of the students for whom online IBL material will be designed is a predictor to take into account, while reading skills, motivation to read and personal interest in science & technology are not related to information integration in an IBL environment.

Keywords: colour-signalling, inquiry-based learning, information integration, individual characteristics

Colour-signalling in Online Inquiry-based Learning Environments

In the current education debate, there is a lot of attention for the education of the future. Among other things, the discussion focuses on the knowledge and skills that are important to prepare pupils for a rapidly changing society (SLO, 2019). Students will have to tackle global and complex challenges in the future and therefore it is advisable to equip them with the so-called twenty-first century learning skills (Scott, 2015). Inquiry-based Learning (IBL) fits well with the learning of these twenty-first century skills, because IBL is a type of active learning that gives priority to critical thinking, data analysis and questioning (Bell, Smetana & Binns, 2005). Though, learning in IBL environments can be troublesome. Students for example sometimes struggle in deciding the right variables to work with, they do not naturally draw correct judgements from experiments, and they find it difficult to state demonstrable hypotheses (De Jong, 2006). However, when students participate in IBL environments it essential that they understand the purpose of the assignments and they must be able to make sense of their results. If not, students cannot conduct investigations that yield meaningful results (Edelson, Gordin, & Pea, 1999). One way to alleviate these problems is by means of scaffolding, like visual signalling. Online environments can integrate cognitive tools like this in the IBL environment (De Jong, 2006). To colour-signal or to label pictures will enhance learners' attention and promote information integration (Yang, Tsai, Chiou, Lee, Chang, & Chen, 2018). Colour-signalling aids students, because this method enhances information integration from text with information from pictures and vice versa (Van Gog in Mayer, 2014, p. 269), resulting in higher learning outcomes. Eye-tracking is suited to measure how people switch with their eyes between the written information and the pictures (Poole & Ball, 2006). A study by Yang et al. (2018) advised to take individual characteristics into account to help science learners effectively integrate relevant information to increase learning outcomes. However, little is known about how various individual characteristics among students relate to their response to colour-signals in terms of eye switching in online IBL environments. The aim of the present study was therefore to investigate how individual characteristics, like *prior knowledge, personal interest, reading skills* and *motivation to read,* among students, would relate to the information integration after the students encounter a colour-signal in an online IBL environment.

Inquiry-based learning

In today's education more and more emphasis is placed on twenty-first century skills to be taught to young learners (SLO, 2018). Twenty-first century skills differ from twentieth century skills mostly due to the rise of sophisticated information and communication technologies. Formal education must be altered to allow new forms of learning to equip students with the right skills to deal with future developments. Twenty-first century education will therefore require more personalized learning with an emphasis on aiding rather than stifling skills like creativity and critical thinking (Jonassen & Grabowski, 2012). IBL embodies an active learning process in which students answer research questions through data analysis (Bell et al., 2005). In IBL environments students are cognitively involved in sense making, developing evidence-based answers, and communicating their conclusions (Hmelo-Silver, Duncan, & Chinn, 2007). They have to discover the solutions to, mostly scientific, problems themselves. In formal disciplines, such as science and mathematics, students not only learn science content but also science processes (Abd-El-Khalick et al., 2004). However, for students to engage in IBL they must know how to execute the tasks that their investigation requires. They need to comprehend the purpose of these practices and they must be able to understand their results, because otherwise they will not be able to deduct useful outcomes. (Edelson et al., 1999). Currently students have trouble with these processes in IBL environments (De Jong, 2006). Jonassen and Grabowski (2012) state that individuals differ in their abilities to process information, create meaning from it, or assign it to new situations. To improve learning outcomes it is therefore desirable to modify the nature of instruction to adapt to differences in capability, style or preferences among individuals (Davies, Fidler & Gorbis, 2011). For tools in IBL environments to be accessible to learners across the full diversity of competences and prior experiences, it is useful to map the influence of individual characteristics. For example, a study by Ho, Tsai, Wang and Tsai (2014) provided evidence to support that without adequate instruction, learners with insufficient prior knowledge may have difficulties in reading scientific information for online inquiry learning. Therefore Ho et al. (2014) advice science educators and curriculum developers to consider how to use text-and- diagram materials for science learners with individual characteristics. A meta analysis based on thirty-three eye-tracking studies in digital environments by Yang et al. (2018) joins in on the advice that individual characteristics, like knowledge, cognitive abilities and cognitive styles should be taken into account. They further advice to help science learners to effectively integrate relevant information, to increase learning outcomes. For instance, visual signalling or labelling pictures will enhance learners' attention and promote information integration (Yang et al., 2018).

This finding ties in with the multimedia principle of Mayer (2014). The multimedia principle states that comprehension in multimedia environments is better when students learn from text and pictures. Multimedia learning occurs when people build mental representations from words (such as spoken text or printed text) and pictures (such as illustrations, photos, animation, or video). Though, in order for students to benefit from text and pictures they have to integrate information generated from text with information generated from pictures. Therefore, multimedia learning can be seen as a sense-making activity in which the student seeks to build a coherent mental representation from the presented material. To help people build coherent mental representations, cueing, signalling or guiding the students' attention to relevant elements of the material is effective (Van Gog in Mayer, 2014, p. 263).

The signalling principle

The signalling principle, also known as the cueing principle, builds on to the multimedia principle and refers to the finding that people learn deeper from a multimedia message when cues are added that guide attention to the relevant elements of the material or highlight the organization of the important material (Van Gog in Mayer, 2014, p. 263). Thus, signalling aids the selection process of participants in two different ways. First, signalling is effective because unnecessary search processes are minimised by relating illustrated and verbal information (Kalyuga, Chandler, & Sweller, 1999). This is in line with Van Gog (in Mayer, 2014, p. 264) who says that signalling reduces extraneous load. Extraneous load is cognitive processing that is not related to the learning objective, like searching. Reducing this load literally creates space in the working memory, making it easier for participants to find relevant information from illustrations or text. Resulting in better integrating corresponding illustrated and verbal information. Second, signalling affects results by guiding the attention of learners by making information that is relevant for the task salient (Ozcelik, Karakus, Kursun, & Cagiltay, 2009). It is likely that signalling is equally effective in IBL environments if they contain written text and pictures, because multimedia learning in short means: Learning from words and pictures (Mayer, 2014, p.3).

Signals come in different forms and can be incorporated into text, a picture or both. Text-based signals are, for instance, sentences that forego the learning material and highlight their structure, or words that are printed in italic. Picture-based signals could be arrows or parts of images that are highlighted by colours. To facilitate the integration of written text and static pictures, like in online IBL environments, colour-signalling can be used to highlight the correspondence between elements of the text and picture by giving them the same colour. Research into graphic design for electronic documents and user interfaces has shown that designers should not use more than five colours at the same time (Marcus, 1991). Using too many colours simultaneously may on itself impose a significant load on working memory and eliminate any positive effect of colour-signalling (Kalyuga et al., 1999).

Individual characteristics among students

Individuals differ in their abilities to process information, make sense out of information, or to apply information to new circumstances (Jonassen & Grabowski, 2012). These individual characteristics lead to different ways of information processing, and different ways in which people will react to information processing-aids like colour-signalling. However, little is known about how students with various individual characteristics respond to colour-signals in multimedia environments, like IBL environments. Therefore the mapping of the influence of individual characteristics can bring colour-signalling in IBL environments one step closer to being effective. A couple of individual characteristics are taken into account based on their relationship to the general learning process. Because multimedia learning is based on information integration from text and pictures it is considered relevant for people to be able to read well and to be motivated to put effort into reading, to take full advantage of the learning material. Furthermore Krapp (1999) found that interest in the topic of the text did not only enhance the amount of remembered text information, but had a strong influence on the quality of learning. Finally, prior knowledge affects the learning process in that it affects how words and pictures are organized in mental models, which in turn relates to what people will learn from materials (Braune & Foshay, 1983).

Reading skills. The first individual difference that is expected to play a role with regard to effectiveness of colour-signalling is reading skills. Afflerbach, Pearson and Paris (2008) defined *reading skills* as automatic actions that result in decoding and comprehension with speed, efficiency, and fluency. Reading skills consist of decoding and comprehension skills (Gough & Tunmer, 1986). Researches have emphasized the importance of decoding. Decoding is necessary for reading, because if print cannot be translated into language, then it cannot be understood. Therefore decoding is primary to comprehension (Keenan, Betjemann, & Olson, 2008). Gough and Tunmer (1986) stated that the skilled decoder is exactly the reader who can read individual words quickly, accurately, and silently; in other words, someone who can read fluently. For students who face a text on a new subject, it might be more relevant to measure reading fluency than to measure comprehension skills. If a student has a lower rate in reading fluency it takes him or her longer to read and understand the texts on new subjects, because new information is accompanied by words that are unfamiliar. If the information is not read fluent, and therefore not comprehended well, it is assumed that the selection and subsequent the integration of information is less likely to take place.

Jian (2017) investigated the cognitive processes and reader characteristics (decoding and comprehension skills) of sixth graders. They read a scientific text with illustrations and were divided into two groups according to their reading performance score. This study showed that readers who's reading score belonged in the upper half made more switching eye-movements between the text and illustrations and that these readers were more interested in illustrations.

Motivation to read. *Reading skills* and *motivation to read* are related to each other, in such a way that *motivation to read* seems an important pre-condition for *reading skills* to come into play (Van den Wouwer, 2011). Constructing meaning during reading is a motivated act. An individual interacting with a text for the purpose of understanding is behaving intentionally (Guthrie & Wigfield, 1999). If the person is not aware of the text, not attending to it, not choosing to make meaning form it, or not giving cognitive effort to knowledge construction, little comprehension occurs. Therefore an explanation of motivation is crucial to an explanation of reading in general.

Motivation to read can be defined as the likelihood of engaging in reading or choosing to read (Gambrell, 2011). *Motivation to read* is usually divided into two distinct parts that play a role in motivation: intrinsic and extrinsic motivation. An intrinsic motivated child likes to read because of personal interest or importance (Van den Wouwer, 2011). When a child is extrinsically motivated the incentive lies outside the child. Motivated readers are motivated to read for different intentions, to use knowledge collected from previous experience, to generate new ideas, and take part in purposeful social interactions around reading (Baker & Wigfield, 1999).

Personal interest in science & technology. When interest and thus learning engagement is higher in a particular instructional circumstance, more mental effort is probably invested, and this is likely to result in a higher performance (Paas, Tuovinen, Van Merrienboer, & Darabi, 2005). Interest can be distinguished into two separate but related forms of interest, which both are relevant for learning, namely; *personal interest in a topic* and situational interest (Paas et al, 2005).

Personal interest is a relatively stable evaluative orientation toward a certain domain. It represents an on-going and deepening relation of a person to a particular topic and it has qualities of full engagement and task orientation (Renninger, 2000). Situational interest, on the other hand, refers to a temporary state of focused attention and the affective reaction that both are triggered by contextual stimuli like specific features of a text (Schiefele, 1999; Schraw, Flowerday, & Lehman, 2001). The two aspects of interest are generated differently.

Personal interest in a topic develops slowly over time and tends to have long-lasting effects on a person's understanding and values. According to Unsworth and McMillan (2013) *personal interest in a topic* has a number of effects: The more interested people are in the topic of a specific text, the higher the likelihood that they read the text deeply, leading to overall better understanding. Situational interest, on the other hand, tends to arise more suddenly by something in the environment and may have only a short-term effect (Trend, 2005).

Personal interest in a topic can be measured beforehand, but situational interest arises in the moment itself. It is interesting to consider the interplay between personal and situational interest. Durik and Harackiewicz (2007) investigated how students with low or high levels of personal interest reacted to material that evoked situational interest. They used mathematics materials with characteristics that were especially designed to catch the attention of the students, like colourful pages with varied fonts and vivid pictures. Durik and Harackiewicz (2007) hypothesized that the “catch attention” condition would be especially effective for boosting situational interest among individuals with low levels of personal interest. This is because the vivid characteristics increase arousal and stimulate curiosity and investigation, which can make the learning experience more appealing for individuals who are otherwise uninterested. It appeared that individuals with low personal interest indeed benefited from the vivid learning environment, in that they were significantly more involved in the math task at hand than students in the non-vivid learning environment.

No studies have been identified yet who examine the relation among *personal interest in a topic* and the related eye-switching. But based on the foregoing it can be assumed that a relation exists between levels of personal interest in a topic and a student’s willingness to focus on the colourful parts of the learning material

Prior Knowledge. *Prior knowledge* has repeatedly been identified as a key factor in predicting what students will learn from instructional materials (Van Gog in Mayer, 2014, p. 264). *Prior knowledge* affects which images and words are selected for processing in working memory and how they will be organized into coherent visual and verbal mental models (Braune & Foshay, 1983). When students encounter a certain topic for the first time, they are presumed to have too little *prior knowledge* of the subject to use as a base for building mental representations from teaching materials. The knowledge they do have is not linked enough or hierarchically organized into a framework to make sense of new information (Cook, Carter, & Wiebe, 2008). Because they have few schemas to process the information, novice learners are left with few reference points for new learning. Therefore, they focus on superficial aspects of representations and therefore they are likely to pay much attention to perceptually salient features (Van Gog in Mayer, 2014, p.264).

Johnson, Ozogul and Reisslein (2015) investigated the moderating effect of *prior knowledge* on visual signalling. Their participants learned to analyse an electric circuit in a computer-based learning environment that included graphs, text and diagrams. Visual signalling was operated by means of arrows that pointed at the right attributes in synchronization with a narrator. This study showed that prior knowledge moderated the effect of the visual signalling. Students with low levels of *prior knowledge* had higher post-test scores after learning with signalling conditions, whereas post-test scores did not differ between signalling and no signalling conditions for the students with high levels of *prior knowledge*.

Present study

Inquiry-based Learning (IBL) fits well with the learning of twenty-first century skills, because IBL is a form of active learning that emphasizes questioning, data analysis and critical thinking (Bell, Smetana & Binns, 2005). Right now students have trouble with IBL (De Jong, 2006). Which is problematic because when students participate in IBL environments they must understand the goals of these practices and they must be able to interpret their results. One way to alleviate these problems is by means of colour-signalling. This will enhance learners' attention and promote information integration (Yang et al., 2018; Van Gog in Mayer, 2014, p. 269), resulting in higher learning outcomes. If IBL is presented in an online multimedia environment, colour-signalling can be applied as scaffold to increase information integration whereby an effective and efficient learning situation is produced, which will in turn increase learning outcomes. The study by Yang et al. (2018) advises to take individual characteristics into account to help science learners to effectively integrate relevant information to increase learning outcomes. Knowledge about the role that individual characteristics might play with regard to information integration after colour-signals is largely unknown. The individual characteristics of *reading skills, motivation to read, personal interest in science & technology* and *prior knowledge* are related to learning outcomes. Their relation with the information integration after a colour-signal was investigated in the present study.

Colour-signalling was implemented as a mean to amplify the information integration between text and pictures for students who engaged in the IBL environment. Therefore the main research question was as follows: How do characteristics among students relate to information integration after a colour-signal in online IBL environments? To examine the effect of the individual characteristics, the following sub-questions were composed: 1) Do the individual characteristics of *reading skills, personal interest in science & technology* and *prior knowledge* cause relate to information integration after a colour-signal in online IBL environments?, 2) Does *motivation to read* moderate the relation between *reading skills* and information integration after a colour-signal in online IBL environments?

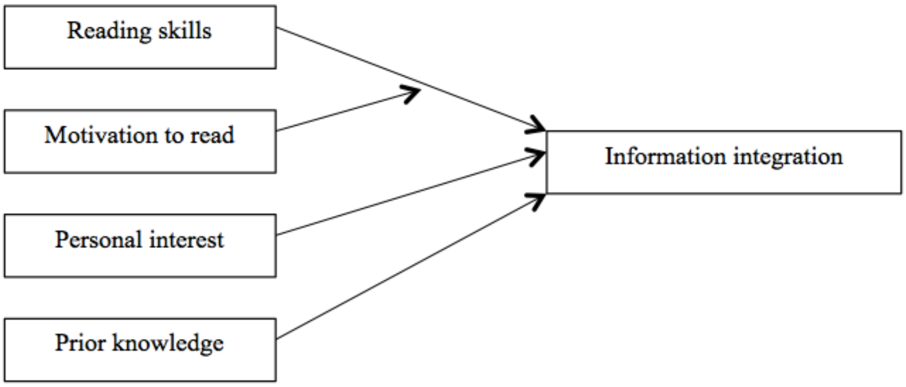


Figure 1: Research model

The following three hypotheses flowed from the foregoing.

Hypothesis 1: Based on the foregoing notion that readers with a better score on reading performance make more switching eye-movements and that they like illustrations better, it was expected that skilled readers made more switching eye-movements after the colour-signal activation. However, *motivation to read* seems a necessary condition for readers to bring their *reading skills* into practice. Students who are unmotivated do not like to put effort into reading, and therefore do not use their *reading skills*. Therefore, it was expected that increasing levels of *reading skills* were related to increasing levels of information integration after a colour-signal and that *motivation to read* moderated this relation.

Hypothesis 2: Students with a lower level of *personal interest in science & technology* will be more prone text characteristics evoking situational interest like colour-signalling. Therefore it was expected that decreasing levels of *personal interest in science & technology* were related to an increasing number of eye-switches after the colour-signal activation.

Hypothesis 3: Colour-signals are designed to be perceptually salient features of the text, and so it is expected that they will capture the attention of students with lower levels of *prior knowledge* more than students with higher levels of *prior knowledge*. Therefore it was expected that decreasing levels of *prior knowledge* were related to an increasing number of eye-switches after the colour-signal activation**.**

Method

Participants

A high-school community in the east of The Netherlands participated in this study. In total 71 (Age *M* = 13.61, *SD* = 0.51) students from the second level of lower vocational training participated. Second level students were selected because these students did not have prior knowledge on the subject that was taught in the IBL environment. After the high-school in question approved participation, all parents gave their consent for the students to participate too. To guarantee complete privacy, participating students received an individual number instead of their own name.

Online inquiry learning environment

The current study was based on an online IBL environment in which participants performed inquiry-based learning. This environment was designed around a science & technology lesson about electricity for students in Dutch lower vocational education. The environment was created on the platform "Go-lab", developed by the department of instruction technology at the University of Twente in an European partnership.

The IBL environment was divided into two separate units, one on the left and one on the right half of the computer screen (see Figure 2). The left part consisted mostly of informative text and examples of electrical circuits. If participants had to form a hypothesis or report their results, they also had to do this on the left part of the screen. The science lab covered the right part of the screen. In this lab participants could build electrical circuits with additions like a voltmeter, ammeter, light bulbs and switches. Participants could test whether their hypotheses were correct in this lab, by reconstructing the appropriate electrical circuits.

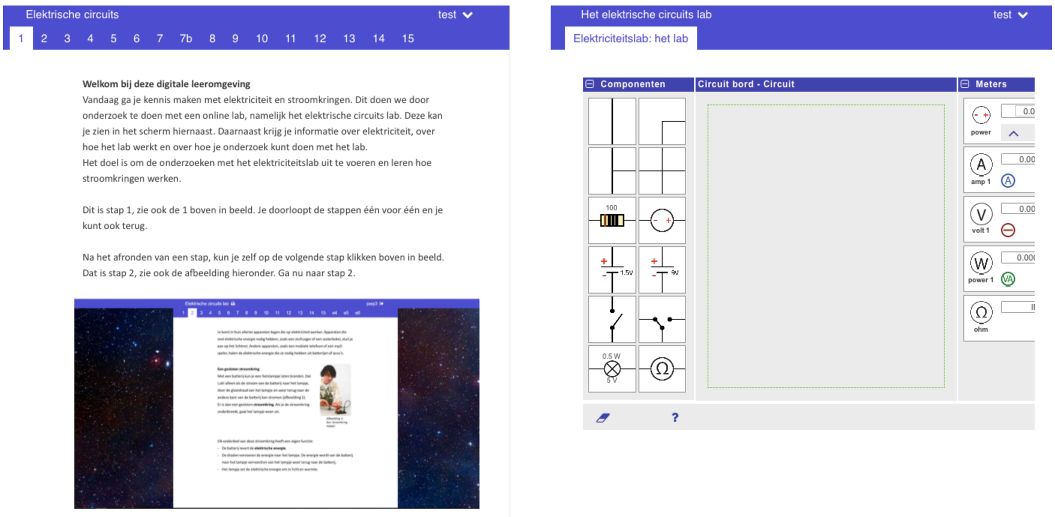


Figure 2. The IBL environment divided into two different parts

The complete IBL environment consisted of 16 pages in total. The pages could roughly be divided into two parts. In the first part, participants were asked first to make a simple circuit with an energy source and a bulb, then the participants had to add a voltmeter and an ammeter to the circuit. With buttons in the science lab participants could adjust the strength of the energy source, causing the bulb to burn brighter or dimmer. Participants then formed several hypotheses by making use of the hypothesis tool (see Figure 3). For example about what they thought would happen when they changed the power of the energy source. Participants could test their hypotheses in the science lab, after which they were invited to report their findings (see Figure 4).

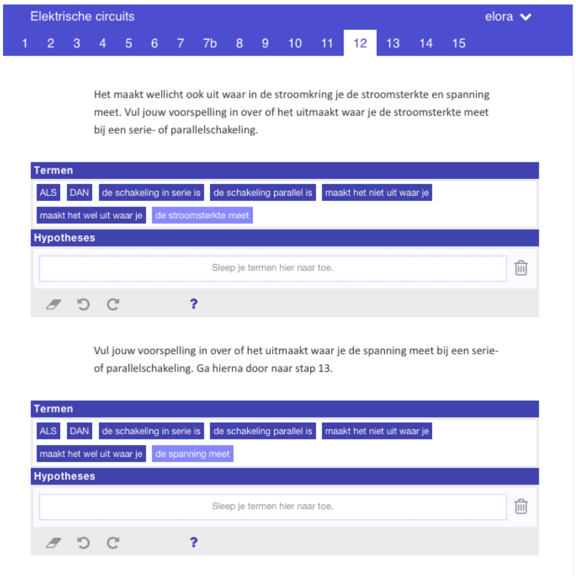


Figure 3. A hypothesis tool in the IBL environment

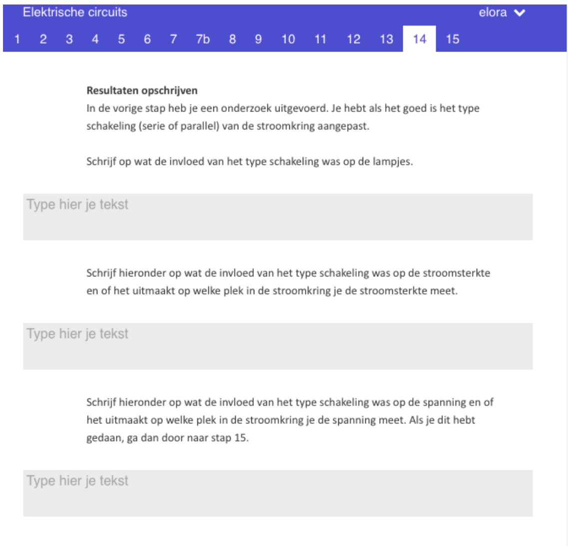


Figure 4. Example of IBL environment section for participants to report results

Once participants completed the first part of the IBL environment by testing their two hypotheses, subject matters did get a bit more complex. Participants were now introduced to the series and parallel connections with one or more bulbs. Participants were invited to create these connections in the science lab and to form a number of hypotheses about them. For example about whether they thought it mattered where in a series or parallel connection one measured the energy strength. On the last page of the IBL environment participants were thanked for their participation. They could also submit questions or comments that they had about the environment.

In the IBL environment colour-signalling was implemented as follows: Four keywords in the text and relation parts in the lab were designed to invite participants to click on them.

Once they did so the colour-signal was activated, causing the keywords and related parts in the lab to light up in the same colour. The IBL environment used in the current research used not more than four colours. The colour-signal word that participants encountered in the IBL environment was “energy source”. Once activated this word lighted up in green (see Figure 5). The remaining three words to be activated were respectively “bulb” (blue), “voltmeter” (yellow) and “ammeter” (red). Once the colours were activated, they remained activated throughout the participants’ session.

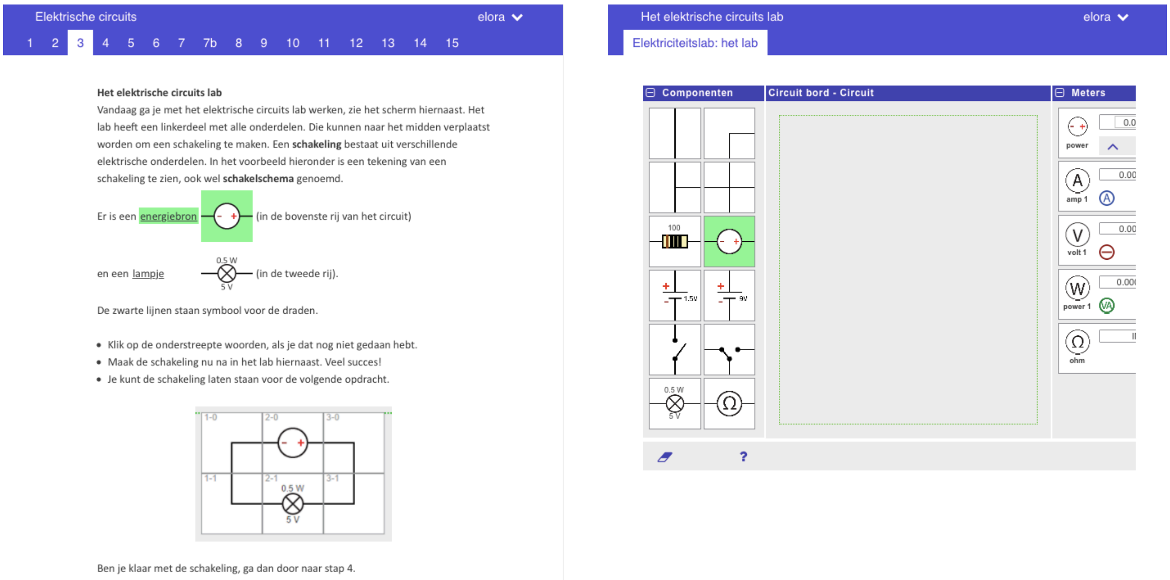


Figure 5. First colour-signal activated

Instrumentation

To gather information about the individual characteristics of *reading skills, motivation to read, personal interest in science & technology* and *prior knowledge*, surveys were held amongst the participants a week before they engaged in the IBL environment.

The *reading skills* were tested by means of the Strikethrough reading-test of Van Bon (2007) (α=.80). This is a test to measure technical reading skills. The test consisted of a list with 90 existing and 30 non-existing words. Participants had to read the list in silence and had to find and cross off as many non-existing words as they could within one minute. Participants could obtain a maximum score of 120, whereby they lost points if they crossed off an existing word or did not cross off a non-existing word.

The *motivation to read* was tested by means of the reading motivation questionnaire (RMQ) by Schiefele and Schaffner (2016). Items of the test were translated to Dutch and reduced from 34 to 21 items. The test comprised both dimensions of *motivation to read: Intrinsic* and *extrinsic motivation to read.* Examples of items were “I Read because it makes me happy" (intrinsic) and "I read because I want to belong to the best of the class" (extrinsic). The participants had to answer to the items on a 4-point scale, ranging from one (not true) to four (very true). The overall test (21 items; α= .94) and subscales of intrinsic (11 items; α=.90) and extrinsic motivation (9 items; α=.83) were reliable. (For the complete test see appendix A).

Personal interest in science & technology was tested by means of the Attitude towards Science & Technology Questionnaire of Denessen, Vos, Hasselman and Louws (2015). This survey consisted of four dimensions and was reliable (20 items; α=.89). The dimensions were about: Thoughts on the level of difficulty in science & technology, thoughts on the importance of science & technology in society, feelings of interest in science & technology and intents to find a job in science & technology in the future. Items were for instance "I find science and technology difficult" and "I think it would be nice to work in science and technology when I grow up*"*. All items were answered on a 4-point scale, ranging from 1 (not true) to 4 (very true). (For the complete test see appendix B).

Prior knowledge was tested by means of a short test consisting of 28 questions. The test was created in accordance with a regular method that schools use to teach science & technology. A sample question is "What is a series connection?", with the following answer options: A) A circuit with a voltage source, B) A circuit with branches, C) A circuit without voltage source, D) A circuit without branches. Each time participants had to pick the right answer out of four options. They could obtain one point per right answered question, thus the maximum score was 28 points. With all questions included the test showed a unreliable Cronbach's Alpha in SPSS (28 items; α=.65). However, some questions reported a higher Cronbach's Alpha if item Deleted, therefore three questions were excluded, resulting in a reliable test with a maximum of 25 items (α=.71). (For the complete test see Appendix C).

Eye-tracking

Eye-tracking is a technique whereby an individual's eye-movements are measured so that the researcher knows both where a person is looking at a given moment and the order in which the person's eyes shift from one place to another (Poole & Ball, 2006). To measure the number of switching eye-movements after the colour-signal the Tobii Pro Glasses 2 in combination with Tobii Pro Lab 2© software was used. These glasses had four eye-cameras (two per eye) to follow the movements of the pupils with a gaze sampling frequency of 50 Hz or 100 Hz (Tobii Pro, 2019).

Procedure

The data collection of all data was conducted over a four-week period in September and October 2018. All four assessments regarding the individual characteristics were held amongst the participants a week before they in the IBL environment. Participants were situated in a large room with computers. After each participant there was an empty spot to ensure that they were sufficiently separated so as not to cheat. The surveys were taken in random order, and every survey was offered to the participants in an online manner except for the Strikethrough reading-test of Van Bon (2007), which was taken on paper. The session lasted for 35 minutes.

A week later two computers were installed in a reserved room at the high-school, equipped with the IBL environment and the Tobii Pro Glasses 2. Since the test is about an online IBL environment, participants participated in the environment via a computer. In consultation with the teachers, participants were taken in random pairs from their courses to participate in the IBL environment. When participants entered the room they received a short explanation about the online lesson they were about to make and that they had to wear glasses. Participants were further instructed to read carefully, to keep their eyes on the screen as much as possible. Then the participants received eye-tracking glasses and made the course while the eye-tracking glasses recorded their eye-movements. Each participant logged on to the IBL environment on one of both computers with his/her personal number. They could ask questions if they needed help. The researcher stayed in the room during the whole session to answer questions if needed, to make sure that all programs ran smoothly and to make sure that participants did not communicate with each other. After participation participants were thanked and accompanied back to their classes.

Analyses

In the online IBL environment participants encountered four similar colour-signals. The number of eye-switches three seconds before and three second after the participants activated the colour-signal were counted. Because it was unknown how long the effects of a colour-signal last in terms of eye-switches, three seconds were taken as checkpoint. However, it may be that effects last longer than three seconds, but when looking at the eye-tracking video data it stood out that the participants switched almost immediately after the colour-signal. Therefore it was expected that the largest effect would be visible within three seconds.

The colour-signals 1 and 2 and the colour-signals 3 and 4 were on the same page in the IBL environment. These signals were both activated within a short amount of time. Thus an overlap existed between the three seconds after activation of colour-signal 1 and before the activation of colour-signal 2. Therefore the eye-switches made in this section might have equally been due to the after-effects of colour-signal 1 or the pre-effects of colour-signal 2. To more accurately measure the change in number of eye-switches caused by the colour-signal, the number of eye-switches before colour-signal 1 were subtracted from the number of eye-switches after signal 2. The same went for signal 3 and 4 respectively. The resulting Change in Switches (CIS) of these calculations was used as the dependent variable to measure the degree of information integration. (CIS 1 = three seconds after colour-signal 2 – three seconds before colour-signal 1, CIS 2 = three seconds after colour-signal 4 – three seconds before colour-signal 3).

Because the participants activated the colour-signals shortly after each other, an anticipation effect was likely to occur. Due to this effect it was expected that CIS 2 would be significantly lower than CIS 1. By performing a paired sample T-test a significant difference between CIS 1 ($M = 1.19$, $SD = 1.19$) and CIS 2 ($M = 0.36$, $SD = 1.00$) was found ($t(68) = 4.20$, $p < .001$, $d = .50$). Indicating that participants at CIS 2 were anticipating more than that they were responding to the colour-signal. In other words, the participants got used to the colour-signal, they expected it, and therefore their response decreased. Therefore the main focus of the results was on the data of CIS 1, henceforth called CIS.

Before the analysis started, the data was checked on outliers, because outliers are an observation or observations very different from most others. Therefore outliers bias statistics and their standard errors and confidence intervals (Field, 2013, p. 165). In the *reading skills* and the *personal interest in science & technology* variables, respectively one and two outliers were found. They were excluded from the data set before the analyses. The other variables had no outliers. Second, to ensure that the relative influences of all measures were comparable for further analysis, standard scores were computed ($M = 0$, $SD = 1$) for the *reading skills, motivation to read, personal interest in science & technology* and *prior knowledge* variables.

Furthermore, to check whether any correlation between the individual characteristics and CIS existed, and to check whether any inter-correlation between the independent variables was present, a correlation matrix was calculated. The significant correlations were classified according to Field (2013, p. 82) who states that $r = .10$ indicates a small effect (1% of the total variance explained), $r = .30$ a medium effect (9% of the total variance explained), $r = .50$ a large effect (25% of the total variance explained). Subsequently a hierarchical multiple linear regression analysis was conducted in two steps. The first step was to calculate if there is a linear relation between one or more individual characteristics and CIS. The second step was to calculate the moderation effect of motivation to read on the relation between reading skills and CIS.

Results

Regarding both research question 1 and 2, the correlations between (CIS) and the predictors were calculated, see Table 1. No significant correlation was found between CIS and the individual characteristics, except for a weak positive linear relation between prior knowledge and CIS. Among the individual characteristics, a moderate negative correlation between *personal interest in science & technology* and *reading skills* was found. The *internal* and *external motivation to read* correlated positively with each other and with the overall *motivation to read.* These correlations were large. Overall the correlations were low.

Table 1

Correlation matrix between individual characteristics and CIS

Variables	1	2	3	3.1	3.2	4	5
1. CIS	-						
2. Reading skills	-.01	-					
3. Motivation to read	.08	-.15	-				
3.1 Intrinsic Motivation to read	.11	-.15	.99**	-			
3.2 Extrinsic motivation to read	.02	-.14	.97**	.91**	-		
4. Personal interest in science & technology	-.01	-.34**	.14	.12	.15	-	
5. Prior knowledge	.26*	.04	.03	.04	.02	-.23	-

* $p \leq .05$, ** $p \leq .01$

To further investigate the relations of the independent variables with CIS, a hierarchical regression was conducted with the variables *reading skills, motivation to read, personal interest in science & technology* and *prior knowledge* in step one and in the interaction between *readings skills* and *motivation to read* was added the second step, see Table 2. The regression models in both steps were not significant, $F(4, 56) = 1.29$, $p = .286$, $R^2 = .08$, and $F(5, 55) = 1.02$, $p = .413$, $R^2 = .09$, respectively. The first step showed that, in line with the correlations, one variable had a significant effect, namely *Prior knowledge*. The other individual characteristics did not relate to CIS. In step two, no moderation effect of *motivation to read* on *reading skills* was found.

Table 2

Hierarchical regression analysis of the predictors in step 1 and the moderation effect of reading skills and motivation to read in step 2 on Change in Switching (CIS)

Variables	ΔR^2	*B*	*SE* (*B*)	β
Step 1				
Reading skills		-.043	.163	-.036
Motivation to read		.090	.164	.072
Personal interest in science & technology		.082	.169	.067
Prior knowledge		.330	.157	.277*
	.084			
Step 2				
Reading skills		-.051	.168	-.042
Motivation to read		.099	.169	.079
Personal interest in science & technology		.085	.171	.069
Prior knowledge		.331	.158	.278*
Reading skills * motivation to read		.036	.154	.032
	.001			
Total R^2_{adj}	.021			

* $p < .05$.

Discussion

The aim of the present study was to investigate the relation of *prior knowledge, reading skills, motivation to read* and *personal interest in science & technology* with the information integration between text and pictures (CIS) and to investigate whether *motivation to read* has a moderation effect on the relation between *reading skills* and CIS. Participants were lower level vocational training students. Results showed that *prior knowledge* was positively related to CIS, and that *Motivation to read* had no effect as a moderator on the correlation between *reading skills* and CIS. Results further showed that no relation existed between CIS and *personal interest in science & technology*.

Motivation to read has no effect as a moderator on the correlation between *reading skills* and CIS. This result indicates that students not necessarily need motivation to bring their reading skills into play. Therefore hypothesis 1 was not confirmed. A meta-study by Morgan and Fuchs (2007) reported that each of the reviewed studies, testing either reading fluency, reading comprehension or both, showed a correlation between children's reading skills and their motivation to read. This correlation did not show up in the current research. A reason could have been that their participants' were in primary school. Therefore their age differed significantly from the average age of the current research, of which participants were already secondary school. Therefore a reason could be that the relation between reading fluency and *motivation to read* no longer exists when students get older. Furthermore, it was noticeable that the average score on motivation appeared to be low (M = 32.25, SD = 11.18). Research by Swarts (2016) showed that the majority of secondary vocational training students is low motivated to read, making it more difficult for this variable to make a difference as moderator.

Results further showed that no relation exists between CIS and *personal interest in science & technology*. Therefore hypothesis 2, according to which it was expected that a negative relation between CIS and personal interest would be present, was not confirmed. The first reason for the absence of the relationship may be that the four colour-signals in the IBL environment were not appealing enough for the participants with lower levels of *personal interest in science & technology.* Earlier research by Durick and Harackiewicz (2007) showed that individuals with high levels of personal interest were more open to the material and invested themselves in the task, because it was presented in a way that was appealing. They had filled their math materials with "colorful pages with varied fonts and vivid pictures". The colour-signals in the current study were designed from a more practical point of view: To stand out against the background to clearly signal the relation between text and pictures. Another reason for the absence of the relation between CIS and *personal interest in science & technology* could be that the efforts of the participants only increase to the extent to which participants care about their well doing on the task (Durick & Harackiewicz, 2007). Perhaps participants in the current research did not care enough about their well doing to increase their efforts in succession of a colour-signal.

Prior knowledge was positively related to CIS; higher levels of *prior knowledge* are related to higher levels of CIS. This finding contradicts hypothesis 3, because instead of a negative linear relationship the results indicate a positive linear relationship. This means that students with a higher level of *prior knowledge* performed more eye-switches after the colour-signal activation than students with a lower level of prior knowledge. This result was not expected, because earlier research showed that students with lower levels of prior knowledge benefitted from instructional guidance provided by the visual signalling, because of the reduction of extraneous load associated with search processes for relevant and corresponding information (Johnson et al. 2015; Van Gog in Mayer, 2014, p.264). However, Jarodzka, Scheiter, Gerjets and Van Gog (2010) concluded in their eye-tracking research that people with higher levels of prior knowledge processed visual information more elaborately and considered more of the relevant information in the beginning of their task processing. A possible explanation for this may be that the students with higher levels of *prior knowledge* know from prior learning experiences which information is relevant to attend to. Due to their expertise on the topic these students would then be more capable of locating and processing the domain relevant information (Ho et al., 2004). Therefore, the students with a higher level of *prior knowledge* in this research were perhaps a little easier triggered to react to the colour-signal, because they knew the signalled information was relevant. Though further research is needed to find out whether higher levels *prior knowledge* would lead to the same results in other learning environments. Because *prior knowledge* that is not related to knowledge of the topic, but more to knowledge of IBL environments and related processes it itself, could also play a part. This type of knowledge was not tested in the current research. An example of such knowledge is intuitive knowledge, which taps on understanding how adjustments of one aspect in the environment affect other aspects and is considered to be a part of conceptual knowledge (Swaak & De jong, 1996).

A moderate negative relation between *personal interest in science & technology* en *reading skills* was found, indicating that as the *reading* skills improve, the *personal interest in science & technology* decreases. This relation is difficult to explain. Perhaps an interest in science & technology results in less interest in reading, like the common difference between students with a preference for Arts or Science studies, and a lower interest in reading results in less developed reading skills over time (Morgan & Fuchs, 2017). Further, the participants in the current research studied lower vocational training, which eminently prepares these students for a more practical profession. Therefore these students might have valued reading as less important or interesting. However, these notions are based on common knowledge and need further research.

Both the *internal* and *external motivation to read* showed a positive relation with each other and with the overall *motivation to read.* This result indicated that when students scored high on the general *motivation to read* variable, they scored high on *intrinsic* and *extrinsic motivation to read* as well. And if either *intrinsic* or *extrinsic motivation* increases, the general *motivation* increases too. In the RMQ by Schiefele and Schaffner (2016) *extrinsic motivation to read* and *intrinsic motivation to read* could be distinguished by more specific sub-components. Between all these sub-components there were intercorrelations with a high significance ($p < 0.001$). This indicated that the *intrinsic* and the *extrinsic* sub-components all relate to each other. The current research focused on *intrinsic* and *extrinsic motivation to read* each as one component, instead of multiple, more specific, components. Because these components were taken together, the chances for the complete variables to correlate with one another increased.

The non-significance of the correlation results and the multiple regression analyses could be due to some limitations in the current research. First, perhaps the colour-signals were put too short in succession in the online IBL environment, resulting in overlap between the three seconds after activation of the first signal and before the activation of the second signal. Therefore it could be questioned whether the eye-switches made in this section were due to the after-effects of colour-signal 1 or the pre-effects of colour-signal 2, leaving the validity to be questioned. A suggestion is therefore to implement a change in the online IBL environment whereby the signals are more spread out, preferably on different pages. This will make it easier to measure the pure differences in eye-switches before and after the colour-signal.

The current group of participants was narrow in terms of demographic data. All participants were students in the age range of 12-14 years and they all took part in the second level of lower vocational training. Further research could take a larger group of participants, including a wider range in age or levels of education. As a result, data can be generalized to larger groups of students and it can be used to further improve IBL for all sorts of people with varying individual characteristics.

The present study provided insights into the relation of individual characteristics among lower level vocational training students with information integration in an online IBL environment enriched with colour-signals. Information integration after a colour-signal cannot solely be predicted based on the current investigated individual characteristics. However, *prior knowledge* related to the information integration after a colour-signal in such a way that students with higher levels of *prior knowledge* performed more eye-switches after the colour-signal activation than students with lower levels of prior knowledge. To increase information integration among students with higher levels of *prior knowledge* it is therefore advised to implement colour-signals in IBL or other multimedia learning environments. However, to increase integration among students with lower levels of *prior knowledge* further research is needed.

In sum, the level of *prior knowledge* of the students for whom material will be designed is an important predictor to take into account. Information integration after a colour-signal cannot solely be predicted based on the current investigated individual characteristics and leaves further research on how to adequately personalize online IBL environments or other multimedia applications in the best way possible.

References

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., ... & Tuan, H. L. (2004). Inquiry in science education: International perspectives. *Science Education*, *88*(3), 397-419.

Afflerbach, P., Pearson, P. D., & Paris, S. G. (2008). Clarifying differences between reading skills and reading strategies. *The Reading Teacher*, *61*(5), 364-373.

Alemdag, E., & Cagiltay, K. (2018). A systematic review of eye-tracking research on MML. *Computers & Education*, *125*, 413-428.

Baker, L., & Wigfield, A. (1999). Dimensions of children's motivation for reading and their relations to reading activity and reading achievement. *Reading Research Quarterly*, *34*(4), 452-477.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. *The Science Teacher*, *72*(7), 30-33.

Braune, R., & Foshay, W. R. (1983). Towards a practical model of cognitive/information processing task analysis and schema acquisition for complex problem-solving situations. *Instructional Science*, *12*(2), 121-145.

Cook, M., Carter, G., & Wiebe, E. N. (2008). The interpretation of cellular transport graphics by students with low and high prior knowledge. *International Journal of Science Education*, *30*(2), 239-261.

Davies, A., Fidler, D. and Gorbis, M. 2011. *Future Work Skills 2020.* Palo Alto, Calif., University of Phoenix Research Institute. www.iftf.org/uploads/media/SR-1382A_UPRI_ future_work_ skills_sm.pdf (obtained on the 11th of December 2018)

Dede, C. (2010). Comparing frameworks for 21st century skills. *21st century skills: Rethinking how Students Learn*, *20*, 51-76.

De Jong, T. (2006). Technological advances in inquiry learning. *Science*, *312*(5773), 532-533.

Denessen, E., Vos, N., Hasselman, F., & Louws, M. (2015). The relationship between primary school teacher and student attitudes towards science and technology. *Education Research International*, *2015*.

Durik, A. M., & Harackiewicz, J. M. (2007). Different strokes for different folks: How individual interest moderates the effects of situational factors on task interest. *Journal of Educational Psychology*, *99*(3), 597.

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*(3-4), 391-450.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE Publications.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and… *Educational psychologist*, *42*(2), 99-107.

Ho, H. N. J., Tsai, M. J., Wang, C. Y., & Tsai, C. C. (2014). Prior knowledge and online inquiry-based science reading: Evidence from eye tracking. *International Journal of Science and Mathematics Education*, *12*(3), 525-554.

Gambrell, L. B. (2011). Seven rules of engagement: What's most important to know about motivation to read. *The Reading Teacher*, *65*(3), 172-178.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*(1), 6-10.

Guthrie, J. T., & Wigfield, A. (1999). How motivation fits into a science of reading. *Scientific Studies of Reading*, *3*(3), 199-205.

Jarodzka, H., Scheiter, K., Gerjets, P., & Van Gog, T. (2010). In the eyes of the beholder: How experts and novices interpret dynamic stimuli. *Learning and Instruction*, *20*(2), 146-154.

Jian, Y. C. (2017). Eye-movement patterns and reader characteristics of students with good and poor performance when reading scientific text with diagrams. *Reading and Writing*, *30*(7), 1447-1472.

Johnson, A. M., Ozogul, G., & Reisslein, M. (2015). Supporting multimedia learning with visual signalling and animated pedagogical agent: moderating effects of prior knowledge. *Journal of Computer Assisted Learning*, *31*(2), 97-115.

Jonassen, D. H., & Grabowski, B. L. (2012). *Handbook of Individual Differences, Learning, and Instruction*. Routledge.

Kalyuga, S., Chandler, P., & Sweller, J. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *13*(4), 351-371.

Keenan, J. M., Betjemann, R. S., & Olson, R. K. (2008). Reading comprehension tests vary in the skills they assess: Differential dependence on decoding and oral comprehension. *Scientific Studies of Reading*, *12*(3), 281-300.

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education*, *14*(1), 23-40.

Marcus, A. (1991). Graphic design for electronic documents and user interfaces. New York: ACM Press.

Mayer, R.E. (Ed.) 2014. *The Cambridge Handbook of Multimedia Learning*. Cambridge: NY. Cambridge University Press.

Morgan, P. L., & Fuchs, D. (2007). Is there a bidirectional relationship between children's reading skills and reading motivation?. *Exceptional children*, *73*(2), 165-183.

Ozcelik, E., Karakus, T., Kursun, E., & Cagiltay, K. (2009). An eye-tracking study of how colour coding affects MML. *Computers & Education*, *53*(2), 445-453.

Paas, F., Tuovinen, J. E., Van Merrienboer, J. J., & Darabi, A. A. (2005). A motivational perspective on the relation between mental effort and performance: Optimizing learner involvement in instruction. *Educational Technology Research and Development*, *53*(3), 25-34.

Poole, A., & Ball, L. J. (2006). Eye-tracking in HCI and usability research. In *Encyclopedia of Human Computer Interaction* (pp. 211-219). IGI Global.

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. *Intrinsic and Extrinsic Motivation* (pp. 373-404).

Scott, L. C. (2015). The Futures of Learning 3: What kind of pedagogies for the 21st century?.

Schiefele, U. (1999). Interest and learning from text. *Scientific Studies of Reading*, *3*(3), 257-279.

Schiefele, U., & Schaffner, E. (2016). Factorial and construct validity of a new instrument for the assessment of reading motivation. *Reading Research Quarterly*, *51*(2), 221-237.

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. *Educational Psychology Review*, *13*(3), 211-224.

SLO Curriculum van de toekomst. (2018). Retrieved from http://curriculumvandetoekomst.slo.nl/21e-eeuwse-vaardigheden/actueel

Stalbovs, K., Scheiter, K., & Gerjets, P. (2015). Implementation intentions during multimedia learning: Using if-then plans to facilitate cognitive processing. *Learning and Instruction*, *35*, 1–15.

Swaak, J., & de Jong, T. (1996). Measuring intuitive knowledge in science: The development of the what-if test. *Studies in Educational Evaluation, 22*, 341–362.

Swarts, N. (2016). *Leesprofielen: verschillen naar leeftijd en geslacht en de relatie met leesprestaties* (Master's thesis).

Trend, R. (2005). Individual, situational and topic interest in geoscience among 11-and 12-year-old children. *Research Papers in Education*, *20*(3), 271-302.

Tobii Pro Glasses 2. (2019). Retrieved from https://www.tobiipro.com/product-listing/tobii-pro-glasses-2/.

Unsworth, N., & McMillan, B. D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(3), 832.

Van Bon, W. H. J. (2007). De Doorstreepleestoets (DLT): Een klassikale toets voor de technische leesvaardigheid.

Van Gog, T., & Scheiter, K. (2010). Eye-tracking as a tool to study and enhance multimedia Learning, 95-99.

Van Kraayenoord, C. E., & Schneider, W. E. (1999). Reading achievement, metacognition, reading self-concept and interest: A study of German students in grades 3 and 4. *European Journal of Psychology of Education*, *14*(3), 305-324.

Van den Wouwer, S. (2011). Leesgedrag en leesmotivatie. Een onderzoek aan de hand van leesdagboeken bij leerlingen uit het vijfde leerjaar.

Walma van der Molen, J.H. (2007). *De ontwikkeling van een attitude-instrument op het gebied van wetenschap en techniek voor leerlingen in het basisonderwijs*. Den Haag: Platform Bèta Techniek.

Yang, F. Y., Tsai, M. J., Chiou, G. L., Lee, S. W. Y., Chang, C. C., & Chen, L. L. (2018). Instructional Suggestions Supporting Science Learning in Digital Environments Based on a Review of Eye Tracking Studies. *Journal of Educational Technology & Society*, *21*(2), 28-45.

Appendix A

1. Ik lees omdat ik er vrolijk van word
2. Ik lees omdat ik door verhalen ga fantaseren.
3. Ik lees omdat ik me graag met bepaalde onderwerpen bezig houd
4. Ik lees omdat ik bij de besten van de klas wil horen.
5. Ik lees omdat mijn ouders het belangrijk vinden dat ik veel lees.
6. Ik lees omdat ik dan iets te doen heb.
7. Ik lees omdat lezen me helpt als ik verdrietig ben.
8. Ik lees omdat ik zo avonturen kan beleven in mijn hoofd.
9. Ik lees omdat ik dan betere cijfers kan halen op school.
10. Ik lees omdat ik me dan niet hoef te vervelen.
11. Ik lees omdat andere mensen zeggen dat lezen belangrijk is.
12. Ik lees omdat ik zo meer kan leren over dingen die ik interessant vind.
13. Ik lees om beter te worden in bepaalde vakken op school.
14. Ik lees omdat ik het dan beter ga doen op school dan mijn klasgenoten.
15. Ik lees omdat ik me graag verplaats in de hoofdpersoon van een verhaal.
16. Ik lees omdat ik mezelf dan bezig kan houden.
17. Ik lees omdat ik dan meer weet dan andere leerlingen.
18. Ik lees omdat lezen me helpt als ik boos ben.
19. Ik lees omdat ik het daardoor beter ga doen op school.
20. Ik lees omdat ik wil dat mijn ouders trots op me zijn.
21. Ik lees omdat ik graag nadenk over bepaalde onderwerpen.

Appendix B

1. Ik vind wetenschap en techniek moeilijk
2. Uitvinders zijn belangrijk voor de samenleving
3. Ik vind het leuk om nieuwe dingen te leren over wetenschap en techniek
4. Het lijkt me leuk om later in de wetenschap en techniek te werken
5. Wetenschappelijke en technische onderwerpen zijn gemakkelijk voor mij
6. Wetenschap en techniek zijn belangrijk voor mij
7. Ik vind het leuk om te leren over wetenschap en techniek
8. Ik wil later graag een wetenschappelijke of technische opleiding doen
9. Wetenschap en techniek is alleen voor slimme mensen
10. Wetenschap en techniek zorgen ervoor dat ons leven makkelijker en prettiger wordt
11. Ik vind het leuk om zelf iets te repareren of in elkaar te zetten
12. Ik zou later best een technisch beroep willen
13. Technische apparaten kunnen alleen gebruikt worden door slimme mensen
14. Wetenschap en techniek zijn belangrijk voor Nederland
15. Wetenschap en techniek is interessant
16. Ik zou later best uitvinder of onderzoeker willen worden
17. Ik kan wetenschappelijke en technische opdrachten zonder al te veel moeite oplossen
18. Wetenschap en techniek zorgen er voor dat het leven van mensen verbetert
19. Ik vind het leuk om dingen uit te vinden
20. Ik wil later graag een baan in de wetenschap en techniek

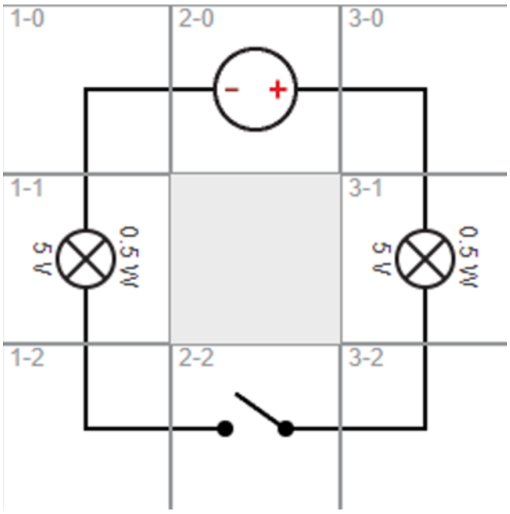
Appendix C

1. Wat is een schakeling?

A. Een lampje in een fitting
B. Een apparaat om de stroomsterkte te meten
C. Een combinatie van elektrische apparaten
D. Een apparaat om de stroom aan en uit te zetten

2. Wat betekent 'elektrische energie'?

A. Het geeft aan hoeveel elektriciteit wordt geleverd en gebruikt
B. Het geeft aan hoe groot de stroomsterkte is
C. Het is de energie die nodig is om een lampje fel te laten branden
D. Het is de energie die opgewekt wordt door beweging



3. Hierboven zie je een afbeelding. Welke uitspraak is *niet waar*?

A. Er is een spanningsbron
B. Het circuit is onderbroken
C. Het circuit is gesloten
D. Er zijn lampjes

4. Wat is de functie van een schakelaar?

A. De accu aan- of uitzetten
B. Een circuit onderbreken of sluiten
C. De spanning meten
D. De accu in een andere versnelling zetten

5. Hoeveel volt is 300 millivolt?

A. 3
B. 30
C. 0,03
D. 0,3

6. Wat is *geen voorbeeld* van een spanningsbron?

A. Batterij
B. Dynamo
C. Accu

D. Circuit

7. Dennis zegt 'De spanning meet je in volt' en Donna zegt 'De spanning meet je in ampère'. Wie heeft er gelijk?

A. Allebei hebben gelijk
B. Dennis heeft gelijk en Donna heeft niet gelijk
C. Dennis heeft niet gelijk en Donna heeft gelijk
D. Allebei hebben niet gelijk

8. Wat is een stroomkring?

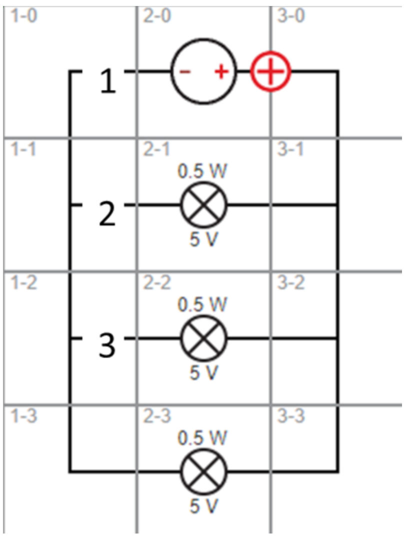
A. Een combinatie van batterijen en elektrische apparaten verbonden door draden
B. Een combinatie van computers verbonden met elkaar via internetkabels en zendmasten
C. Een combinatie van tandwielen verbonden met kettingen
D. Een spanningsbron

9. Stel je hebt een lampje en een stroombron aangesloten. Als de stroom van de bron toeneemt, wat gebeurt er dan met de stroomsterkte en de spanning?

A. De stroomsterkte neemt toe en de spanning neem toe
B. De stroomsterkte neemt af en de spanning neemt af
C. De stroomsterkte neemt af en de spanning neem toe
D. De stroomsterkte neemt toe en de spanning neem af

10. Wat is een serieschakeling?

A. Een schakeling met een spanningsbron
B. Een schakeling met vertakkingen
C. Een schakeling zonder spanningsbron
D. Een schakeling zonder vertakkingen

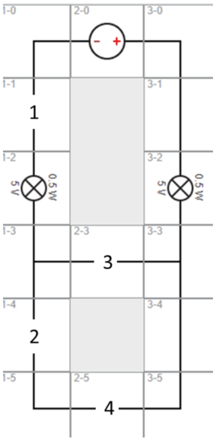


11. Hierboven zie je een afbeelding. Cecile wil weten wat de spanning is als ze de lampjes aan zet. Daarom gaat ze die op drie plekken meten. De + van de spanningsmeter heeft ze al geplaatst. De - nog niet. Wat zal de spanning zijn?

A. De spanning is overal hetzelfde
B. De spanning is op plek 1 het grootst, daarna op plek 2, en het kleinst op plek 3
C. De spanning is op plek 1 het kleinst, daarna op plek 3, en het grootst op plek 3
D. De spanning is hetzelfde op plek 1 en 2 en de spanning op plek 3 is het kleinst

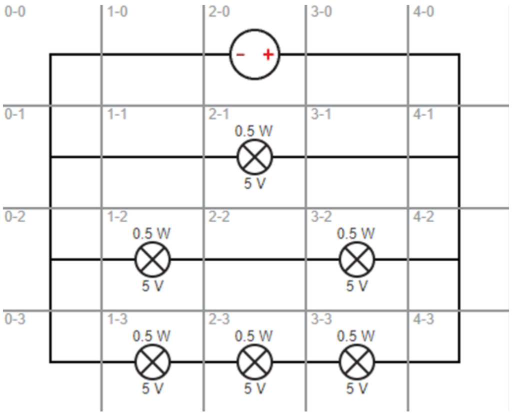
12. Met een ampèremeter meet je:

A. De spanning
B. De stroomsterkte
C. De weerstand
D. Het voltage



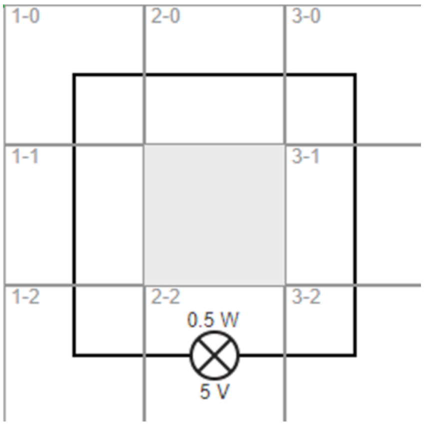
13. Hierboven zie je een afbeelding. Stel je wilt beide lampjes aan en uit kunnen zetten met een schakelaar. Waar zou je de schakelaar dan plaatsen?

A. Plek 1
B. Plek 2
C. Plek 3
D. Plek 4



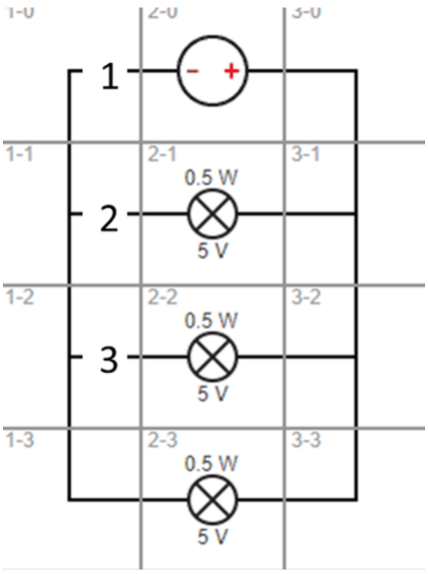
14. Hierboven zie je een afbeelding. Als je de elektrische energie aanzet, hoe fel zullen de lampjes dan branden?

A. Op elke rij even fel
B. Op de bovenste rij het felst en de onderste rij het minst fel
C. Op de bovenste rij het minst fel en de onderste rij het felst
D. Op de bovenste rij het felst en op de middelste en onderste rij even fel



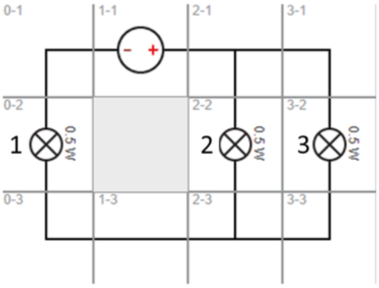
15. Hierboven zie je een afbeelding. Waarom brandt het lampje niet?

A. Het circuit is gesloten
B. Er is geen stroommeter
C. Het circuit is te groot
D. Er is geen spanningsbron



16. Hierboven zie je een afbeelding. Jack wil weten wat de stroomsterkte is als hij de lampjes aan zet. Daarom gaat hij die op drie plekken meten. Wat zal de stroomsterkte zijn?

A. De stroomsterkte is overal hetzelfde
B. De stroomsterkte is op plek 1 het grootst, daarna op plek 2, en het kleinst op plek 3
C. De stroomsterkte is op plek 1 het kleinst, daarna op plek 2, en het grootst op plek 3
D. De stroomsterkte is op plek 1 het grootst en op plek 2 en 3 gelijk

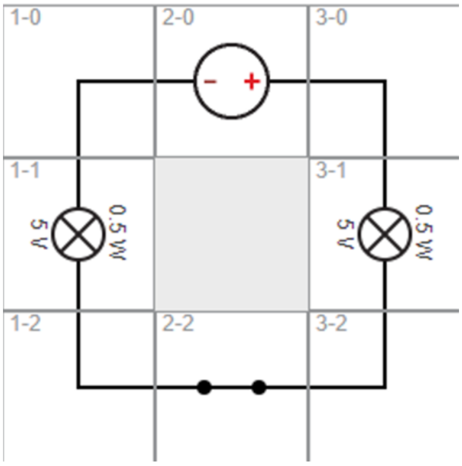


17. Hierboven zie je een afbeelding. Carlo draait lampje 3 los. Wat gebeurt er met de andere twee lampjes?

A. Lampje 1 gaat uit en lampje 2 blijft branden
B. Lampje 1 blijft branden en lampje 2 gaat uit
C. Lampje 1 en 2 gaan allebei uit
D. Lampje 1 en 2 blijven allebei branden

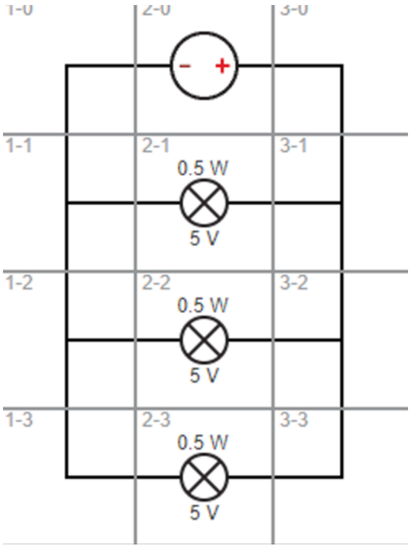
18. Hoeveel milliampère is 2,5 ampère?

A. 250
B. 2500
C. 25
D. 0,025



19. Hierboven zie je een afbeelding. Welke uitspraak is *niet waar*?

A. Er is een spanningsbron
B. Het circuit is onderbroken
C. Het circuit is gesloten
D. Er zijn draden



20. Hierboven zie je een afbeelding. Hoe noemen we een dergelijke afbeelding?

A. Een plattegrond
B. Een stroommeter
C. Een schakelschema
D. Een schakelaar

21. Wat is een parallelschakeling?

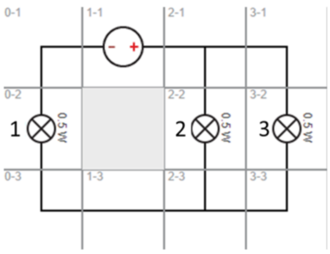
A. Een schakeling met een spanningsbron
B. Een schakeling met vertakkingen
C. Een schakeling zonder spanningsbron
D. Een schakeling zonder vertakkingen

22. Bob zegt 'De stroomsterkte meet je in volt' en Rita zegt 'De stroomsterkte meet je in ampère'. Wie heeft er gelijk?

A. Allebei hebben gelijk
B. Bob heeft gelijk en Rita heeft niet gelijk
C. Bob heeft niet gelijk en Rita heeft gelijk
D. Allebei hebben niet gelijk

23. Wat is *geen voorbeeld* van een elektrisch apparaat?

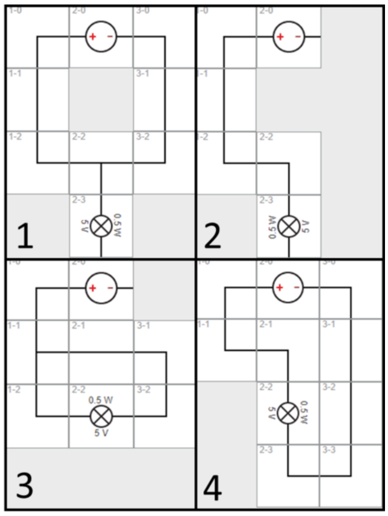
A. Mobiele telefoon
B. Lampje
C. Stofzuiger
D. Magneet



24. Hierboven zie je een afbeelding. Carla draait lampje 1 los. Wat gebeurt er met de

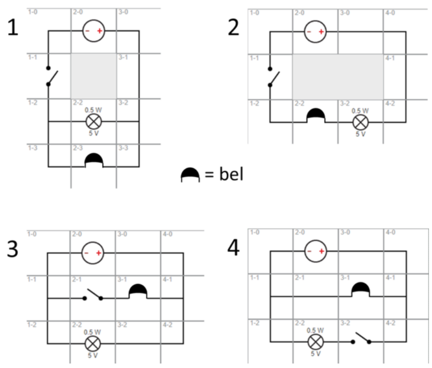
andere twee lampjes?

A. Lampje 2 gaat uit en lampje 3 blijft branden
B. Lampje 2 blijft branden en lampje 3 gaat uit
C. Lampje 2 en 3 gaan allebei uit
D. Lampje 2 en 3 blijven allebei branden



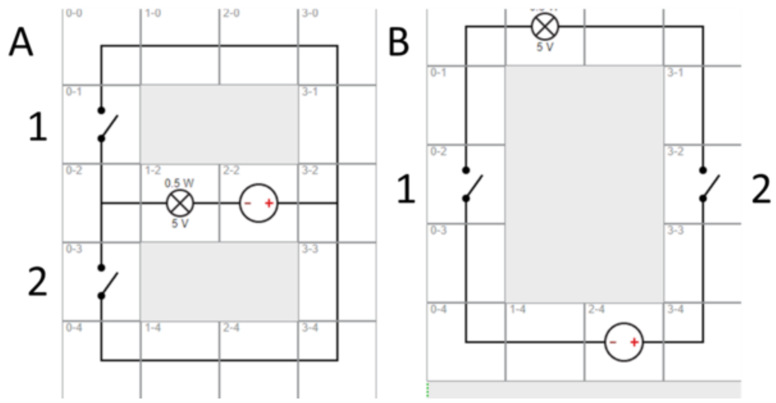
25. Hierboven staat een afbeelding. Bij welke van de vier zal het lampje branden?

A. 1
B. 2
C. 3
D. 4



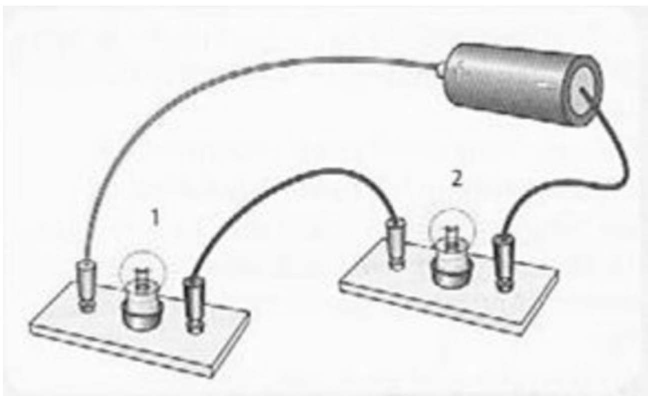
26. Sommige deurbellen hebben drukschakelaars met een ingebouwd lampje dat altijd brandt. Daardoor is de drukschakelaar ook in het donker steeds makkelijk te vinden. Hierboven staat een afbeelding. Welke van de vier hoort bij de beschreven situatie?

A. 1
B. 2
C. 3
D. 4



27. Hierboven staat een afbeelding. Moeten de schakelaars 1 en 2 gesloten of open zijn, zodat de lamp brandt? Kies hieronder de juiste uitspraak.

A. Bij afbeelding A moet één schakelaar open zijn en bij afbeelding B moet één schakelaar gesloten zijn
B. Bij afbeelding A moet één schakelaar gesloten zijn en bij afbeelding B moeten beide schakelaars gesloten zijn
C. Bij afbeelding A moeten beide schakelaars gesloten zijn en bij afbeelding B moet één schakelaar gesloten zijn
D. Bij afbeelding A moeten beide schakelaars open zijn en bij afbeelding B moet één schakelaar gesloten zijn



28. De opstelling in de tekening hierboven is een:

A. Serieschakeling
B. Parallelschakeling
C. Kun je niet zeggen
D. Allebei