MASTER THESIS

Effect of specificity of guidance on gifted children's learning process, learning outcomes, mood and flow during inquiry-based learning in science education.

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November, 2021

Abstract

Purpose of the study was to examine the effect of specificity of guidance on gifted children's learning process, learning outcomes, mood and flow during inquiry-based learning in science education. A total of 82 Dutch gifted children of grade five, six, seven and eight were divided into three experimental conditions, receiving non-specific, average specific or specific guidance. In this pre-posttest between subject design, children of all conditions worked individually on an inquiry task using worksheets offering guidance. During the learning task, children's mood was measured. After experimenting, children's flow experience and knowledge acquisition was assessed. Children's worksheets were analysed to gain insight in the learning process. Results showed no significant differences between the three conditions on learning outcomes and flow. There was a significant difference in neutral mood, however, only visible in one of three measurement times. Looking at the learning processes, results indicated that children in the specific condition had drawn significantly more correct conclusions. Thus, specific guidance appears to be the most effective guidance type in supporting gifted children during inquiry learning.

Keywords. giftedness, inquiry learning, guidance, learning process, learning outcomes, flow, mood.

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Introduction

Last decades, researchers in the educational field became even more convinced that during science education, learners should be engaged in active investigation and experimentation to enhance motivation and learning outcomes (De Jong & Lazonder, 2014; Abd-El-Khalick et al., 2004; Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). A suitable method to reach this objective is inquiry learning (Lazonder & Harmsen, 2016). Inquiry learning is defined by the National Science Foundation (2000) as a pedagogical approach in which students generate hypotheses, conduct experiments, and draw conclusions based on the collected data. During inquiry learning, the target information is not presented to the learner, but is to be discovered by the learner with the provided materials (Alfieri et al., 2011). This enables students to become active agents of their own learning process (Gijlers & De Jong, 2005).

Part of research on inquiry learning is directed towards gifted children. Inquiry learning is considered a pedagogical approach fitting the instructional needs and learning characteristics of gifted children (Eysink, Gersen, & Gijlers, 2015). In order to learn from inquiry learning, learners should be able to self-monitor their learning process, which requires considerable metacognitive skills (Alfieri et al., 2011). Gifted children are characterized by good metacognitive skills, and show great self-regulatory skills (DeCorte, 2013; Sternberg, 2001). They also prefer to self-manage and self-monitor their learning process, and favour less teacher monitoring (Risemberg & Zimmerman, 1992). Based on these characteristics and preferences, education to the gifted should be active and open-ended while stimulating higher level thinking and problem solving (Van Tassel-Baska, 2013). Since inquiry-learning enables students to be active agents of their own learning process (Gijlers & De Jong, 2005), this approach satisfies the requirements of education for gifted children. Thus, inquiry learning can be used to provide gifted children with adaptive education. Adaptive education to gifted children’s instructional needs and learning characteristics is important. When education is not cognitively challenging enough, it can cause academic underachievement amongst this group and the opportunity to maximize gifted children’s full potential can be obstructed (Reis & Renzulli, 2004; Reis & Renzulli, 2010; Reid & Boettger, 2015). In order to maximize gifted children’s full potential, a high level of motivation is required according to Rea (2000). When education to the gifted matches their educational needs they are more likely to have positive moods (Reis & Renzulli, 2010) and to report flow (Rea, 2000; Clinkenbeard, 2012; Johnsen, 2009), indicating a higher level of motivation.

Research has shown that inquiry learning in science is more effective in terms of learning outcomes than other, more expository instructional approaches, as long as appropriate guidance is offered (e.g., Alfieri et al.,2011; Lazonder & Harmsen, 2016). According to Lazonder and Harmsen

(2016), the effectiveness of inquiry learning depends almost entirely on guidance. Without appropriate guidance, children within the inquiry process experience difficulties formulating hypotheses (Piekny & Maehler, 2012), evaluating evidence (Piekny, Grube, & Maehler, 2014) and establishing the independent or dependent factors (Pedaste & Sarapuu, 2014). Eysink et al. (2015) showed that gifted children also benefit from guidance during inquiry tasks. Gifted children receiving guided inquiry learned more, reported more flow and a more positive mood than gifted children in an open or exposed inquiry environment (Eysink et al., 2015). However, since guidance takes many forms, it is still unclear what kind of guidance is most effective for gifted children. In order to optimize inquiry learning for gifted children, research should be conducted on types of guidance suitable for gifted children.

Theoretical framework

Giftedness

For decades past, researchers and psychologists directly equated giftedness with high IQ (De Corte, 2013). Further examination amongst gifted people has expanded the definition of giftedness beyond IQ towards a multidimensional construct of giftedness, including a variety of traits, skills and abilities which are manifested in various ways (Reis & Renzulli, 2004). Research on characteristics points out that gifted children share a variety of traits, aptitudes and behaviours which can be perceived as distinctive characteristics for the gifted across different cultures (Reis & Renzulli, 2010). In relation to learning, the gifted differentiate from nongifted children in their learning skills (Sternberg, 2001) and learning preference (Risemberg & Zimmerman, 1992).

Gifted students are able to think critically and creatively (Sternberg, 2001). They process knowledge in a different way: gifted students can separate irrelevant information from relevant information, and are well capable to transfer new knowledge to existing knowledge stored in memory (Shore, 2000; Sternberg, 2001). In comparison to peers, the gifted are better in problem recognition, strategy formulation and self-monitoring learning (Shore, 2000; Sternberg, 2001), which makes them good problem solvers (Reis & Renzulli, 2010). Also, their ability to organise and work systematically is well developed (Sabanci & Bulut, 2018). Through these good metacognitive skills and their ability to reason logically, gifted students are good in performing inquiries according to Reis and Renzulli (2010). Gifted students not only excel cognitively, but also stand out in self-regulatory skills (Sternberg, 2001). They can focus for long periods and show more motivation and persistence over time (Shore, 2000; Reis, 2005). They effectively control their pace of study, and are aware of and capable of adjusting their errors (Risemberg & Zimmerman, 1992). With these strong self-regulatory skills, gifted students are more likely to restructure the learning environment to fit their learning needs (Risemberg & Zimmerman, 1992).

So, gifted children as a whole in comparison with nongifted children use more self-regulatory skills and use learning strategies that are more advanced cognitively. They carry out trained or spontaneously generated strategies more effectively according to Risemberg and Zimmerman (1992). Moreover, gifted students generally have higher prior knowledge (Sternberg, 2001). With regard to their learning preference, gifted students are independent, which entails that they prefer individualized study to lectures or other forms of whole-class instruction (Risemberg & Zimmerman, 1992). Because of these learning skills and learning preferences, gifted students have different learning needs in comparison with peers. In order to satisfy these needs, education to the gifted should not consist of an extreme form of discovery learning, but there should be a shift to active learning whereby guidance is provided to gifted individuals (De Corte, 2013)

Inquiry learning and inquiry learning processes

Inquiry learning is an instructional approach often used in science education. The active and constructive learning in inquiry approaches results in the implication of different inquiry learning processes (De Jong & Lazonder, 2014; Alfieri et al., 2011). Njoo (1994) identified these inquiry learning processes and made a classification, in which a distinction is made between transformative processes (analysis, hypothesis generation, testing, evaluation) and regulative processes (planning, monitoring, verifying).

The four transformative processes are subdivided into more detailed processes. The analysis processes cover the search for information about the domain and identifying the variables involved. This can be done on basis of prior knowledge, additional material or from data already obtained from experimentation (Gijlers & De Jong, 2005). According to Njoo (1994) the hypothesis generation process is important, since the learners' mental model of a domain is build upon the acceptation or rejection of a hypothesis. The experimentation process include activities concerning designing and executing the experiments. The interpretation processes concern interpretation of the data and results. Evaluation processes refer to reflecting on experiments and putting results in a broader context. Through the transformative processes, knowledge is yielded directly, which is not the case with the regulative processes (Njoo, 1994; De Jong & Van Joolingen, 1998). The regulative processes of planning, monitoring and verifying are present during all transformative processes and are necessary to control the inquiry process (de Jong & Van Joolingen, 1998). The learning processes during inquiry learning do not appear in a sequential order, but proceed in iterative cycles (De Jong & Lazonder, 2014; Njoo, 1994; Klahr en Dunbar, 1988).

The learning processes are significant for the effectiveness of an inquiry (Njoo, 1994). However, research shows that inquiry learning is a complex activity calling upon learning processes and a set of skills few students are found to master (De Jong & Lazonder, 2014; Zimmerman, 2000). Learners encounter difficulties in generating and adapting testable hypotheses and data interpretation, while they often have poorly designed experiments and experience problems regarding regulation of learning (De Jong & Lazonder, 2014; Reid, Zhang, & Chen, 2003). Moreover, in order to make sense of the learning material learners should select relevant information, make coherent structures of this information, and transfer new information to existing knowledge (Alfieri et al., 2011). Selecting, structuring, and integrating in a task appropriate way turns out to be an arduous task for many learners according to Alfieri et al. (2011). Learners need considerable metacognitive skills to monitor their learning process and focus on relevant information, and these skills are often not developed appropriately (Kirschner, Sweller & Clark, 2006). Therefore, unguided or open inquiry learning is generally ineffective according to Mayer (2004). A meta-analysis of Alfieri et al. (2011) shows that across domains and settings, inquiry learning with no or minimal guidance is less effective than traditional, more expository forms of instruction. However, when learners are presented with adequate guidance, the inquiry approach is more effective than explicit instruction (Alfieri et al., 2011; Furtak, Seidel, Iverson, & Briggs, 2012).

Guidance

Guidance can be described as any form of assistance offered before or during inquiry learning (Lazonder & Harmsen, 2016). Guidance can be provided to learners intensively or minimally, and both can take many forms such as manuals, simulations, feedback and example problems (Alfieri et al., 2001). Since the term ‘guidance’ can be explained very broadly, multiple researchers have made a classification of different types of guidance to be able to further specify. Most of the time, these classifications are designed in terms of learning activities it aims to support (f.e. Reid et al., 2003; Quintana et al, 2004). For example, Reid et al. (2003) distinguished among interpretative support, helping students structuring their knowledge, experimental support, helping students setting up and interpreting experiments, and reflective support, helping students in reflecting on their learning process. But there are many more ways to organize the type of guidance learners receive. De Jong and Lazonder (2014) state that both the amount of guidance and the provided type of guidance should be adapted to learners’ prior knowledge and skilfulness to accomplish effective inquiry learning.

A typology that can be used to determine the appropriate instructional guidance for inquiry learning based on knowledge and skills of learners is the framework from De Jong and Lazonder (2014). This framework is organized according to the increasing specificity of support learners need to successfully conduct their inquiry (De Jong & Lazonder, 2014). Since it is expected that gifted children in comparison to peers differ in both knowledge and skills, this framework is likely to be suitable in determining the appropriate instructional guidance for this group. In this framework, the least specific type of guidance is called *process constraints*. Process constraints restrict the comprehensiveness of the inquiry task by diminishing the number of options students need to consider (Lazonder & Harmsen, 2016). An example of a process constraint is the division of the task into manageable subtasks. Process constraints are intended for learners who are able to perform basic inquiry processes, but lack experience regulating inquiry processes under more demanding circumstances (Lazonder & Harmsen, 2016). By order of specificity, the second type of guidance is called *status overview*. Status overviews make task- or learning progress visible for learners who lack skills to plan and monitor their learning according to De Jong and Lazonder (2014). Third, *prompts* are timed cues that remind the learner to perform a certain action (Lazonder & Harmsen, 2016). Prompts are intended for learners who are capable of performing the action but may not do so without a reminder (De Jong & Lazonder, 2014). Fourth, *heuristics* offer more specific guidance than prompts and can be provided to learners who do not know when and exactly how an action should be performed (Lazonder & Harmsen, 2016). Heuristics not only remind the learner of a certain action, but also propose a possible way to perform the action according to De Jong and Lazonder (2014). Fifth, *scaffolds* provide designated means to carry out a learner's action (De Jong & Lazonder, 2014). They explain or take over parts of the inquiry, and are suitable for learners who lack skills to perform the action themselves or cannot perform the action on memory (Lazonder & Harmsen, 2016). Scaffolds often structure the process for students by presenting them with components. An example of a scaffold can be found in the online collaborative discovery learning environment Co-Lab, used in the study of Van Joolingen et al. (2005). In this environment, the overall structure of an inquiry cycle is made visible to the learners. In this structure, slots are provided enabling students to write down their findings and experiences. The last type of support, *explanations*, include direct presentations of information about the performance of an inquiry skill and science topic, before or during inquiry learning (Lazonder & Harmsen, 2016). This most specific type of support is intended for learners who lack prior knowledge and are unable to discover target information individually (Lazonder & Harmsen, 2016).

According to Lazonder and Harmsen (2014), developmental research suggests that less experienced learners with low prior knowledge benefit from more explicit guidance, such as heuristics, scaffolds, and explanations. Learners with high prior knowledge and skills are expected to benefit most from the light forms of guidance such as process constraints, status overviews and prompts (De Jong & Lazonder, 2014). Providing these experienced students with explicit guidance is likely to be counterproductive for performance, which is known as the expertise reversal effect (Kalyuga, 2007; De Jong & Lazonder, 2014). The expertise reversal effect can occur when experienced learners are confronted with instructional guidance which overlaps with existing knowledge in their working memory (Kalyuga, 2007). The cross-referencing and integration of both components requires additional working memory resources and might therefore cause cognitive overload according to Kalyuga (2007). Gifted learners are more skilful than other learners and are more likely to have higher prior knowledge (Sternberg, 2001). Therefore, it can be expected that the expertise reversal effect can occur when gifted students are provided with too much or too explicit guidance.

Flow and mood

Motivation is an essential key to talent development (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2005; Rea, 2000). The problem with gifted underachievers is not a lack of intellectual ability, but a lack of motivation (Little, 2012). This lack of motivation is often caused by a mismatch between educational opportunities and gifted children's motivational needs (Rea, 2000). Motivation is important for creative productivity and accomplishments of gifted children and therefore, educators should focus on enhancing motivation when stimulating talent development according to Rea (2000). The optimal experience of intrinsic motivation is called flow (Csikszentmihalyi et al., 2005). The flow concept can be described as:

> A subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself. The defining feature of flow is intense experiential involvement in moment-to-moment activity. Attention is fully invested in the task at hand, and the person functions at his or her fullest capacity (Csikszentmihalyi et al., 2005, p. 600).

Flow emerges when an individual's capability matches the challenge level of a task (Csikszentmihalyi et al., 2005; Rea, 2000; Clinkenbeard, 2012; Johnsen, 2009). A task that is too difficult leads to anxiety and frustration, a task that is not challenging enough leads to boredom (Clinkenbeard, 2012; Johnsen, 2009). When children experience a proper balance between skills and challenge, they feel strong and have high expectations of success (Rea, 2000). There is also an affective component to motivation (Rea, 2000). Affection can be conceptualized as a positive versus a negative mood, and concerns the manner a student emotionally reacts to the task (Rea, 2000). Positive moods include excitement and an alert level of relaxation, associated with curiosity, explorations, challenge, control, skilfulness and mastery (Clinkenbeard, 2012; Rea, 2000). Emotions considered as negative moods are stress, anxiety, boredom, apathy and overexcitement, which can interfere with attention, performance and persistence (Philips & Lindsay, 2006; Rea, 2000).

Clinkenbeard (2012) states that gifted children are unlikely to experience flow when a learning task is too easy. They show greater motivation and a more positive mood when learning materials fit their educational needs (Reis & Renzulli, 2010). Therefore, both flow experience and mood during a task are indicators of a match between the learning task and gifted children's educational needs. Research of Eysink et al. (2015) showed that gifted children in guided inquiry experienced more flow and felt more positive towards the task than gifted children in an unguided or exposed inquiry environment. Therefore, it can be concluded that even though gifted children prefer to self-manage their learning process, external regulation in the form of guidance during inquiry learning does not automatically negatively affects gifted children's mood and flow experience. Yet, it is still unknown what type of guidance elicits the most positive mood and more experience of flow.

This study

This study aims to find an answer on how guidance can be tailored to gifted children's learning needs and characteristics during inquiry learning, using the framework of specificity of guidance from De Jong and Lazonder (2014). This leads to the following research question:

Research question:

'What is the effect of the specificity of guidance on the learning process, learning outcomes, mood, and flow of gifted children during inquiry learning in science education?'

In order to answer the research question, the types of guidance of the framework from De Jong and Lazonder (2014) were divided into three groups: (a) non-specific guidance, concerning process constraints and status overviews, (b) average specific guidance, concerning prompts and heuristics, (c) and specific guidance, concerning scaffolds and explanations. By pairing two guidance types to each other, close to each other concerning level of specificity, a reliable comparison between effect of specificity of guidance can still be made, while it requires a smaller number of participants.

The research question is supported by the following hypotheses. The first hypothesis states that the highest scores on learning process and learning outcomes result from the average specific guidance. The expectation is that the specific guidance does not align with gifted children's high prior knowledge, and their good metacognitive and self-regulatory skills. Therefore, the specific guidance is expected to obstruct the learning process and to be counterproductive in terms of learning outcomes, which is in line with the expertise reversal effect as explained by Kalyuga (2007). Research of Eysink et al. (2015) demonstrated that gifted children do benefit in terms of learning outcomes from guidance during inquiry learning. The non-specific guidance types are light forms of guidance. It is expected that the non-specific types of guidance do not offer enough support in guiding gifted children's inquiry learning processes. The average specific guidance is expected to support the learning process enough without obstructing it, offering gifted children a proper balance between task complexity and skill, resulting in higher learning outcomes as a result of a more efficient learning process.

The second hypothesis states that gifted children in the experimental condition with the highest scores on learning process and learning outcomes also experience the most flow. This is based on Rea (2000), Clinkenbeard (2012), Johnsen (2009) and Csikszentmihalyi et al. (2005), all claiming that learners are more likely to experience flow when there is balance between the complexity of a task and the skills of the learner.

The third hypothesis is based on Sternberg (2001) who found that gifted children prefer individualised learning with less teacher monitoring. Since the non-specific guidance types, process constraints and status overviews, are light forms of guidance the non-specific guidance condition seems to satisfy gifted children's preference to self-manage their learning task. Therefore, it is expected that children in the non-specific guidance condition show a more positive mood. Since the specific guidance types do not seem to correspond with gifted children's learning preference, it is expected that children in the specific guidance condition show the least positive mood.

Method

Research design

To evaluate the effect of the independent variable 'type of guidance' on the dependent variables knowledge acquisition, flow, and mood, a pre-posttest between subject design with three experimental conditions was applied. Type of guidance had three levels differing in level of specificity of guidance, based on the typology of inquiry learning guidance of De Jong and Lazonder (2014). The levels concerned non-specific guidance (offering process constraints and status overviews), average specific guidance (offering prompts and heuristics) and specific guidance (offering scaffolds and explanations).

Participants

A total number of 96 Dutch gifted children participated in the study. All participants had a measured IQ of 130 or higher. They either attended a school for gifted students or a weekly pull-out class for gifted students. Thirteen participants were excluded from the data file since data of one of the sessions was missing. One participant was excluded because he was not able to focus during the task. The remaining 82 participants (46 boys, 36 girls) were in grade three, four, five or six of elementary education, with a mean age of 10.45 (SD= .96). All children were randomly assigned to one of the three experimental conditions. The first condition, receiving the non-specific guidance, consisted of 25 participants (11 boys, 14 girls) with a mean age of 10.42 (SD=.96). The second condition, receiving the average specific guidance, consisted of 30 participants (18 boys, 12 girls) with a mean age of 10.31 (SD=.84). The third condition, receiving the specific guidance, consisted of 27 participants (17 boys, 10 girls) with a mean age of 10.63 (SD=1.08). All parents and/or legal guardians had given permission for participation of their child in the current study.

Materials

Electricity set. Children performed inquiries with the GIGO 1184 electricity set of PMOT. This set is specifically designed for children and suitable for building electrical circuits. The set consisted of four double-sided base grids, four base connectors, five red and five black wire connectors, two battery holders, two batteries, two bulb holders, two bulbs and a switch.

Learning task. Children worked individually on a learning task in the science domain of electricity. Subjects covered were: the electrical circuit and bulbs, conductors and insulators, and the effect of the amount of bulbs and batteries. The learning task consisted of five inquiry tasks: (a) investigate which materials you need to let a bulb burn, (b) investigate the difference between an open and a closed electrical circuit, (c) investigate how a switch works, (d) investigate which materials from the classroom can or cannot be used to let a bulb burn, and (e) investigate whether and how the number of bulbs and batteries influences the intensity of the light. Task a, b, and c focused on the subject: 'the electrical circuit and bulbs', task d focused on the subject 'conductors and insulators' and task e focused on 'the effect of the amount of bulbs and batteries'.

Worksheets non-specific, average specific, and specific guidance. Three different worksheets were presented to learners of the different conditions (see Appendices A, B and C for complete worksheets). These paper-and-pencil worksheets were designed to guide learners through the five inquiry tasks. All worksheets contained the guidance type: 'process constraints', through the division into five subtasks. This is consistent with the definition of process constraints of Lazonder and Harmsen (2016), who stated that process constraints should diminish the number of options students need to consider. In combination with the process constraints, the worksheet providing non-specific guidance used status overviews, the worksheet providing average specific guidance used prompts and heuristics, and the worksheet providing specific guidance used scaffolds and explanations.

In the non-specific worksheet, status overview was offered for each of the five inquiry tasks by use of a progress bar, which made task progress visible by indicating how many tasks were already completed from the total amount of tasks (See Figure 1). A white space was presented after each inquiry task in which children could write down their conclusions.

Figure 1

Example task 1 non-specific guidance worksheet


Vraag 1 van de 5

Welke materialen heb je nodig om een lampje te laten branden?

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Probeer het lampje te laten branden door te experimenteren.

Je mag hier jouw antwoord opschrijven:

....

....

The structure of the average specific and specific worksheet is presented in Table 1. In the average specific and specific worksheet, both prompts and scaffolds were aimed at the inquiry core process: drawing conclusions. Also, in the specific guidance worksheet scaffolds were aimed at hypothesis generation. The heuristics in the average specific guidance worksheet and the explanations in the specific guidance worksheet were aimed at the Control Variable Strategy (CVS): the manipulation of one variable at the time while the other variables remain constant. Also, heuristics and explanations were presented concentrating on the core inquiry process hypothesis generation. Furthermore, in the specific guidance worksheet, explanations were provided, presenting a small amount of information on the inquiry subject in one to four sentences after each inquiry task. The guidance in the average specific and specific worksheet predominantly focused on guiding the same aspects. The existing differences are inherent to the characteristics and applicability of the guidance types. For example, the scaffolds in the specific worksheet also focused on hypothesis generation in addition to drawing conclusions. The addition of the hypothesis generation to the fill-in scheme was a logical additive to the clear display of the scheme. The prompts in the average specific guidance worksheet did not offer this opportunity, the addition of an prompt on hypothesis generation would overlap with the heuristic. Moreover, explanations also focused on the inquiry subject in addition to CVS and hypothesis generation. This in consistent with the characteristics of explanation as described in the framework of De Jong and Lazonder (2014). Explanations are intended for learners who lack prior knowledge and include direct presentations of information about the performance of an inquiry skill and the science topic.

Table 1

Structure of the average specific guidance and specific guidance worksheet.

Worksheet	Type of support	Basic idea support type	Worksheet presentation form	Guidance focus point
Average specific guidance	Prompts	Reminder to perform a certain action	Tip to remind the learner to perform a certain action	1.Drawing conclusions
	Heuristics	Reminder to perform an action and suggest how to perform the action	Suggestion of a possible way to perform the proposed action in one to two sentences	1.Control variable strategy 2.Hypothesis generation
Specific guidance	Scaffolds	Explain or take over the more demanding parts of an action	Fill-in scheme	1.Drawing conclusions 2.Hypothesis generation
	Explanation	Specify exactly how to perform an action	Direct presentation of information	1.Control variable strategy 2.Hypothesis generation 3.Inquiry subject

In the average specific guidance worksheet, for each of the five inquiry tasks one prompt and two heuristics were presented. The prompt was presented in the form of a tip, reminding the learner to perform a certain action. This is consistent with the description from De Jong and Lazonder (2014). The heuristics suggested a possible way to perform a proposed action, as described by De Jong and Lazonder (2014). From the two heuristics, one focused on the CVS and one focused on hypothesis generation. A white space was presented after each inquiry task in which children could write down their conclusions.

In the specific guidance worksheet, for each of the five inquiry tasks, one scaffold and three explanations were presented. The scaffold was presented in the form of a fill- in scheme, taking over demanding parts of the inquiry process, similar to the definition of scaffolds of De Jong and Lazonder

(2014). From the three explanations, one explanation focused on CVS, and one focused on hypothesis generation. A third explanation was provided, presenting a small amount of information on the inquiry subject in one to four sentences after each inquiry task. These explanations were direct presentations of information, consistent with the framework of De Jong and Lazonder (2014) (See Table 1).

An example of the average specific guidance worksheet is presented in Figure 2, concerning task one: 'Investigate which materials you need in order to let a bulb burn'. Beside a short presentation of the task, a heuristic was presented directed at hypothesis generation: 'Before you start experimenting, first make a prediction. So, first, think about whether or not you need the material.' Thereafter, the presentation of the task continued: 'Try to let the bulb burn through experimenting.' Consequently, a heuristic focused on CVS was presented: 'Determine if you really need the material to let the bulb burn. You can do this by removing one material at a time from your electrical circuit.' Lastly, the prompt was presented: 'Tip: write down which materials you need to let the bulb burn!'

Figure 2

Example task 1 average specific guidance worksheet


Welke materialen heb je nodig om een lampje te laten branden?

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Maak eerst een voorspelling voordat je gaat experimenteren. Dus denk eerst goed na of je het materiaal nodig hebt.

Probeer het lampje te laten branden door te experimenteren. Bepaal of je een materiaal echt nodig hebt om het lampje te laten branden. Dit kun je doen door één materiaal per keer te verwijderen uit jouw stroomkring.

Tip: Denk eraan om de materialen die je nodig hebt op te schrijven!

Je mag hier jouw antwoord opschrijven:

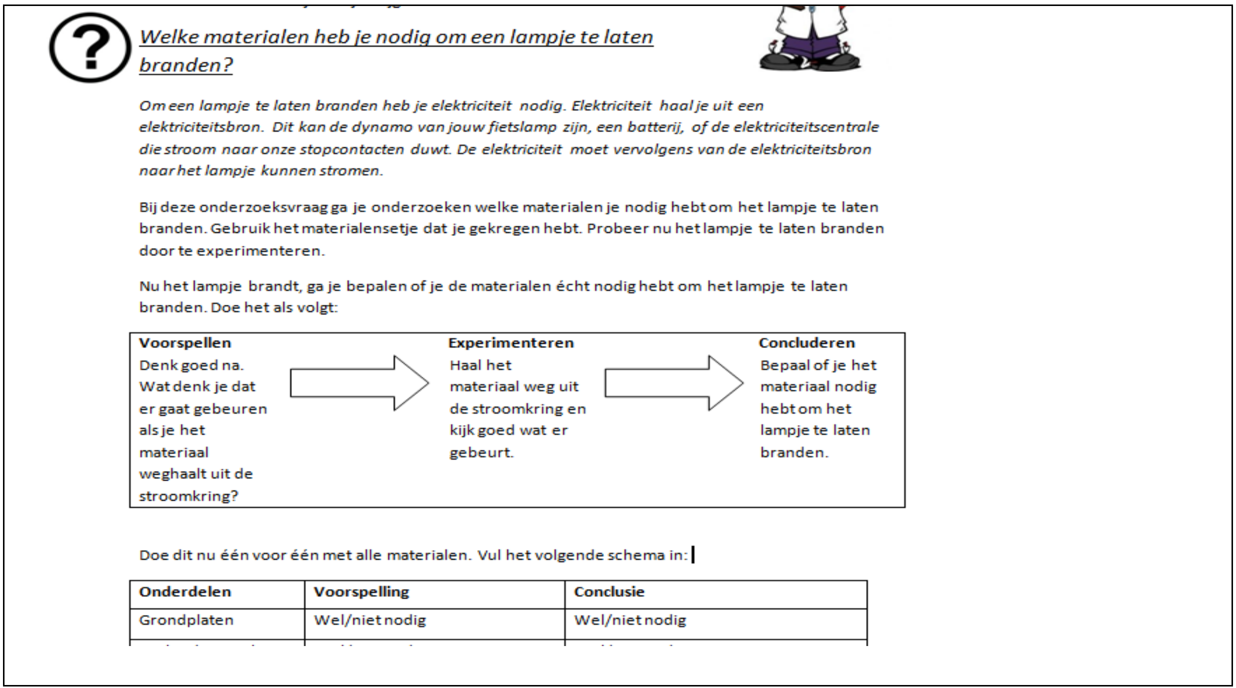
....

....

An example of the specific guidance worksheet is presented in Figure 3, also concerning inquiry task one. First, a short explanation of four sentences on the inquiry subject was presented: 'In order to let the bulb burn, electricity is needed . . . The electricity should flow from the electrical source to the bulb.' Thereafter, the explanation on hypothesis generation was presented, through a systematic display of the inquiry core processes hypothesis generation, experimentation, drawing conclusions. Subsequently, an explanation on CVS was presented: 'Now, perform this action one by one with the different materials.' Lastly, a scaffold was offered, aiming at writing a conclusion by means of a fill-in scheme.

Figure 3

Example task 1 specific guidance worksheet



Welke materialen heb je nodig om een lampje te laten branden?

Om een lampje te laten branden heb je elektriciteit nodig. Elektriciteit haal je uit een elektriciteitsbron. Dit kan de dynamo van jouw fietslamp zijn, een batterij, of de elektriciteitscentrale die stroom naar onze stopcontacten duwt. De elektriciteit moet vervolgens van de elektriciteitsbron naar het lampje kunnen stromen.

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Probeer nu het lampje te laten branden door te experimenteren.

Nu het lampje brandt, ga je bepalen of je de materialen écht nodig hebt om het lampje te laten branden. Doe het als volgt:

Voorspellen		Experimenteren		Concluderen
Denk goed na. Wat denk je dat er gaat gebeuren als je het materiaal weghaalt uit de stroomkring?	→	Haal het materiaal weg uit de stroomkring en kijk goed wat er gebeurt.	→	Bepaal of je het materiaal nodig hebt om het lampje te laten branden.

Doe dit nu één voor één met alle materialen. Vul het volgende schema in:

Onderdelen	Voorspelling	Conclusie
Grondplaten	Wel/niet nodig	Wel/niet nodig

Knowledge pre-test. Children's prior knowledge about electricity was assessed by a knowledge pre-test designed by Eysink, Gersen and Gijlers (2015). Questions focused on basis conceptual knowledge about electricity, such as circuit theory. The test consisted of eleven open questions, for which 22 points could be earned. Questions were assessed using an answer sheet (see Appendix D). Reliability of this test was measured with Crohnbach's α as α= .55. Two items were deleted, resulting in a reliability of α= .59.

Knowledge post-test. Children's learning outcomes were assessed by a knowledge post-test about electricity, designed by Eysink et al. (2015). This test contained the same eleven open questions as included in the pre-test, supplemented with four other open questions. Topics addressed in the four additional questions were based on key concepts and relations that could have been inferred from the worksheets' five inquiry tasks. A total of 40 points could be earned. Questions were assessed using an answer sheet (see Appendix E). Reliability of all 15 items was measured with Crohnbach's α as α= .63.

Flow measurement. Children's perception of flow was measured by the Dutch translation of the Flow Short Scale of Rheinberg, Vollmeyer and Engeser (2003) (see Appendix F). The questionnaire contained 9 items. An example was: 'I don't need rewards. The joy in doing these assignments was enough'. All items were rated by children using a 7-point Likert scale, with higher scores indicating more flow. The reliability of the Dutch version was measured with Cronbach's α as α=.83.

Mood measurement. Children's mood was measured by an adapted version of the smileyometer from Read, Farlane and Casey (in Zaman, De Grooff, Vanden Abeele, 2013) (see Appendix G). Children were, a three appointed times in their learning task, proposed with the question: 'How do you feel about this task?'. Subsequently, children could rate their mood by choosing between six smileys, representing moods ranging from 'awful' to 'brilliant'. The two most negative smiley's are considered as 'negative mood', the two middle smiley's are considered as 'neutral mood', and the two most positive smiley's are considered as 'positive mood'.

Learning process. Children's learning process was assessed by the number of correct conclusions drawn on the worksheets. Children in all three experimental conditions were asked to write down a conclusion after each of the five subtasks. In the non-specific and average specific guidance condition worksheet a blank space was provided for writing down conclusions. In the specific guidance condition worksheet, fill-in schemes were presented for writing down conclusions. For each of the five correct conclusions, one point could be earned. Conclusions were assessed using an answer sheet (see Appendix H). To assess inter-rater reliability, 9 worksheets (randomly selected) were also assessed by a second rater. Cohen's kappa was calculated with this data, and was found to reflect an excellent level of inter-rater agreement (K = .82).

Procedure

The experiment took place in two sessions, held at the locations of the schools of the children. During the first session, a short introduction on the research context was given. Thereafter, all children received 30 minutes to fill in the knowledge pre-test. During the second session, children were randomly divided to one of the three experimental groups. In turn, these groups were taken to another classroom where they worked individually with the intervention. Children performed an inquiry, with help of the electricity set and worksheet, for about 45 minutes. At three appointed moments in their learning process, after inquiry task 3, 4, and 5, they were asked to fill in the smileyometer and report the time. After finishing their inquiry, children were asked to fill in the flow measurement. When all three groups were finished, all children together in the classroom received 35 minutes to fill in the knowledge post-test.

Results

Prior knowledge

Table 2 displays the mean scores and standard deviations for learners of all three conditions on the knowledge pretest. A Kruskal- Wallis ANOVA indicated that there were no significant differences between the results of the knowledge pretest assigned to participants in the non specific guidance condition (*Mean Rank* = 38.56), the average specific guidance condition (*Mean Rank* = 37.78), and the specific guidance condition (*Mean Rank* = 48.35), $H = 3.38$, $df = 2$, $N = 82$, $p = .184$, $\eta^2 = 0.04$. This indicates that, on average, children of all three conditions had the same amount of prior knowledge concerning electricity.

Time on task

Table 2 displays the means and standard deviations for learners of all three conditions on total time spent on the learning task. A Kruskal-Wallis ANOVA indicated that there were significant differences between the total time spent on the learning task of children from the non specific guidance condition (*Mean Rank* = 26.54), average specific guidance condition (*Mean Rank* = 44.82), and specific guidance condition (*Mean Rank* = 51.67), $H = 15.41$, $df = 2$, $N = 82$, $p = .00$, η2 = .19. Multiple comparison analyses using a Bonferroni adjusted alpha showed that children in the non specific guidance condition spent significant less time on the learning task than children in the average specific guidance condition, $U = 211.00$, $z = -2.78$, $p = .005$, and children in the specific guidance condition, $U = 127.50$, $z = -3.85$, $p = .000$. No significant difference was found between children in the average specific and specific guidance condition on total time spent on the learning task, $U = 340.50$, $z = -1.03$, $p = .302$. Looking at the assumptions for time on task as a covariate for measuring conceptual knowledge acquisition and flow, the linearity assumption was violated. This indicates that the usage of time on task as a covariate in these measurements is inappropriate.

Knowledge

Table 2 displays the mean scores and standard deviations for learners of all three conditions on the knowledge posttest. A one-way between groups analysis of variance (ANOVA) was used to investigate the impact that specificity of guidance had on conceptual knowledge acquisition of electricity. Results were non-significant, F (2, 82), $p = .498$, $\eta^2 = 0.02$. This indicates that children's acquired knowledge on the posttest was not impacted by the specificity of guidance. A paired samples *t* test was used to compare gifted children's score on the pretest to their score on the identical questions on the posttest. On average, learners of all conditions scored 0.84 point higher on these questions during the posttest than they did during the pretest. This difference was significant, $t(81)=2.90$, $p = .005$, $d = .30$, which indicates that on average, children learned from the learning task.

Table 2

Mean scores and standard deviations on knowledge pretest, total time on task, knowledge posttest and flow experience for each experimental condition.

	Experimental condition					
	Non-specific guidance (*N* = 25)		Average specific guidance (*N* = 30)		Specific guidance (*N* = 27)	
	M	SD	M	SD	M	SD
Knowledge pretest (max.18)	13.20	2.73	12.83	3.48	14.18	3.16
Total time spend on learning task	25.48	7.25	32.27	8.76	35.30	9.33
Knowledge posttest (max. 40)	25.60	6.03	26.07	6.10	27.56	6.68
Knowledge posttest identical questions pretest (max. 18)	13.80	0.54	13.50	0.45	13.63	0.50
Experienced flow (max. 63)	49.44	2.00	46.50	1.76	49.04	1.68

Looking at the three conditions separately, a significant difference was found between scores on pretest and scores on the identical questions on the posttest for the non-specific guidance condition ($t(24)=2.62$, $p < .001$, $d = .42$), average specific guidance condition ($t(29)=2.15$, $p = .006$, $d = .40$) and specific guidance condition ($t(26)=.395$, $p < .001$, $d = .07$). Gifted children's score on the identical questions during the posttest was on average 1.08 point (non-specific guidance condition), 1.23 point (average specific guidance condition), and .19 point (specific guidance condition) higher than their pretest score. This indicates that children of all three conditions on average learned from the learning task.

Flow

Table 2 displays the means and standard deviations for learners of all three conditions on flow experience. A Kruskal-Wallis ANOVA indicated that were no significant differences between the flow experience of children from the non specific guidance condition (*Mean Rank* = 45.80), average specific guidance condition (*Mean Rank* = 37.10), and specific guidance condition (*Mean Rank* = 42.43), $H = 1.878$, $df = 2$, $N = 82$, $p = .391$, $\eta 2 = .023$. This indicates that children's flow experience was not impacted by the specificity of guidance.

Table 3

Percentages on mood for each experimental condition.

	Experimental condition								
	Non-specific guidance (*N* = 25)			Average specific guidance (*N*= 30)			Specific guidance (*N*= 27)		
	Pos.	Neu.	Neg.	Pos.	Neu.	Neg.	Pos.	Neu.	Neg.
Mood measurement 1	84.0	4.0	12.0	80.0	13.3	6.7	63.0	29.6	7.4
Mood measurement 2	76.0	12.0	12.0	73.3	23.3	3.4	70.4	29.6	0.0
Mood measurement 3	76.0	24.0	0.0	80.0	16.7	3.3	70.4	25.9	3.7
Mean	78.7	13.3	8.0	77.8	17.8	4.4	67.9	28.4	3.7

Mood

Table 3 displays the percentages on mood for each experimental condition. A Kruskal-Wallis ANOVA was used to investigate the impact guidance type had on total score on mood. Results showed no significant differences between the mood of children from the non specific guidance condition (*Mean Rank* = 36.42), average specific guidance condition (*Mean Rank* = 42.38), and specific guidance condition (*Mean Rank* = 45.22), H = 1.879, df = 2, N =82, p = .391, η2 = .023.

Three Pearson chi-square tests of contingencies were used to evaluate whether guidance type is related to positive mood at any time of measurement. The chi-square tests were not significant at measurement one, χ^2 (2,82) = 3.61, p = .165, measurement two, χ^2(2,82) = .210, p = .900, and measurement three χ^2 (2,82) = .718, p = .699. Concerning neutral mood, two Pearson chi-square tests and one Fisher's Exact test were used to evaluate whether guidance type is related to neutral mood at any time of measurement. The test was significant at measurement one (p = .042, Fisher's exact test). The tests were not significant at measurement two, χ^2 (2,82) = 2.41, p = .300, and measurement three, χ^2 (2,82) = 0.80, p = .671. Concerning negative mood, three Fisher's Exact tests were used to evaluate whether guidance type is related to negative mood at any time of measurement. The tests were not significant at measurement one (p = .787), measurement two (p = .108), and measurement three (p =1.000). The results indicated no significant differences in positive mood and negative mood between the three experimental conditions at any time of measurement. There was a significant difference in neutral mood, however, only visible in one of three measurements.

Table 4

Unstandardised (B) and standardised (β) regression coefficients and squared semi- partial correlations (sr^2) for each predictor in a regression model predicting conceptual knowledge acquisition.

Variable	*B* [95% CI]	Β	*sr^2*
Mood	.122 [-0.76, 0.52]	-.052	-.00
Flow experience	.209 [0.03, 0.39]*	.316	.06

*Note. N = 82. CI = confidence interval. * p < .05*

Flow, mood and knowledge

To assess the size and direction of the linear relationship between flow, mood, and knowledge a Kendall's tau-b was calculated. Results indicated the presence of a small positive correlation between knowledge acquisition and mood, τ = .16, *p* =.049, two tailed, *N* = 82, and between knowledge acquisition and flow, τ = .18, *p* =.024, two tailed, *N* = 82. A medium, positive correlation was found between flow and mood, τ = .48 *p* < .001, two tailed, *N* = 82.

To estimate the proportion of variance in conceptual knowledge acquisition that can be accounted for by mood and flow experience, a multiple regression analysis was conducted. Results showed that in combination, flow experience and mood significantly predicted conceptual knowledge acquisition. The results of the regression indicated that the two predictors explained 8.2% of the variance, *F* (2, 82) = 3.54, *p* =. 034, R^2 =.082, adjusted R^2 = .059. Results showed that mood alone did not significantly predict conceptual knowledge acquisition (*B* = -.052, β = .122, *p* = .705). It was found that flow significantly predicted conceptual knowledge acquisition, (*B* = .316, β =.209, *p* = .023). This implies that, after controlling for mood, the score on flow experience increased with .316 for each point earned on the knowledge posttest. This shows that children's flow experience positively influenced their conceptual knowledge acquisition. Unstandardised (*B*) and standardised (β) regression coefficients, and squared semi- partial correlations (sr^2) for each predictor in the regression model are reported in Table 4.

Learning process

Table 5 displays the means and standard deviations for learners of all three conditions on total score on correct conclusions drawn during the learning task. A Kruskal-Wallis ANOVA indicated that there were significant differences between the number of correct conclusions drawn during the learning task of children from the non specific guidance condition (*Mean Rank* = 39.16), average

Table 5

Mean scores and standard deviations on correct conclusions drawn during the learning task for each experimental condition.

	Experimental condition					
	Non-specific guidance (N = 25)		Average specific guidance (N = 30)		Specific guidance (N = 27)	
	M	SD	M	SD	M	SD
Correct conclusions (max. 5)	1.64	0.99	1.40	0.89	2.30	1.17

specific guidance condition (*Mean Rank* = 32.83), and specific guidance condition (*Mean Rank* = 53.30), H = 12.01, df = 2, N =82, p = .002. This effect can be described as large (η2 = .148).

Multiple comparison analyses using a Bonferroni adjusted alpha showed no significant difference between children in the non specific and average specific guidance condition on correct conclusions, U = 318.00, z = -1.056, p =.291. Results showed that the number of correct conclusions drawn during the learning task of children from the specific guidance condition was significantly higher than those of children from the non-specific guidance condition, U = 222.00, z = -2.201, p =.028, and children from the average specific guidance condition, U = 202.00, z = -3.441, p =.001. This indicates that specific guidance positively influenced the correct conclusions drawn during the learning task.

Flow, mood and learning process

To assess the size and direction of the linear relationship between flow, mood, and the learning process a Kendall's tau-b was calculated. Results indicated the presence of a small positive correlation between learning process and flow, τ = .19, p =.030, two tailed, N = 82. No significant correlation was found between learning process and mood, τ = .15, p =.089, two tailed, N = 82.

To estimate the proportion of variance in score on learning process that can be accounted for by mood and flow experience, a multiple regression analysis was conducted. Results showed that in combination, flow experience and mood significantly predicted the score on learning process. The results of the regression indicated that the two predictors explained 10.4% of the variance, F (2, 82) = 4.58, p =. 013, R^2 =.104, adjusted R^2 = .081. Results showed that mood alone did not significantly predict score on the learning process (B = .014, β = .035, p = .798).

Table 6

Unstandardised (B) and standardised (β) regression coefficients and squared semi- partial correlations (sr²) for each predictor in a regression model predicting score on learning process.

Variable	*B* [95% CI]	Β	*sr²*
Mood	.014 [-0.95, 0.12]	.035	.00
Flow experience	.034 [0.01, 0.06]*	.300	.06

*Note. N = 82. CI = confidence interval. * p < .05*

It was found that flow significantly predicted score on the learning process, (*B* = .034, β =.300, *p* = .029). This implies that, after controlling for mood, the score on flow experience increased with .034 for each point earned on the learning process. This shows that children's flow experience positively influenced their score on the learning process. Unstandardised (*B*) and standardised (β) regression coefficients, and squared semi- partial correlations (*sr²*) for each predictor in the regression model are reported in Table 6.

Discussion

Aim of the present study was to examine the effect of specificity of guidance on gifted children's learning outcomes, mood, and flow during inquiry learning in science education. Gifted children participating in the present study were divided into three experimental conditions, receiving either non-specific guidance (process constraints and status overviews), average specific guidance (prompts and heuristics) or specific guidance (scaffolds and explanations) . Gifted children's learning process, learning outcomes, flow and mood of the three experimental conditions were compared to answer the research question.

The first hypothesis predicted that the average specific guidance would create a learning environment with a proper balance between task complexity and gifted children's skills. This balance was expected to enhance the learning process, resulting in higher learning outcomes. However, looking at the results, none of these expectations were confirmed. Concerning the learning process, it was found that gifted children receiving specific guidance had drawn significantly more correct conclusions during inquiry learning in comparison to the non-specific or average specific guidance condition. An explanation for this finding could be found by taking a deeper look into the guidance received by the experimental conditions through the worksheets.

The offered guidance in the non-specific condition, process constraints and status overviews, are both very light forms of guidance. These types of guidance do not offer much support to the learner in structuring the learning task, the learning task still remains quite open. Prior research of Eysink et al. (2015) already showed that unstructured discovery tasks are not most effective for gifted children’s learning. The guidance types in the average specific condition, prompts and heuristics, offer more support to the learner by providing reminders to perform a certain action, and short suggestions of a possible way to perform a proposed action. However, it does not go beyond reminders and suggestions, and it does not support the learner to a large extent in structuring the learning task. This is the difference with the specific types of guidance: explanations and scaffolds, which offer more structure to the learner. The explanations in this study provided a small amount of information on the inquiry subject, and specified exactly how to perform the inquiry (e.g. the use of CVS, hypothesis generation). The scaffolds presented the learner with relevant variables by means of fill- in schemes children could use to generate hypotheses and draw conclusions. The presentation of relevant variables and the structure of the fill-in scheme stimulated the children to work systematically and study all relevant variables. So, the scaffolds and explanations supported learners in structuring the learning task and therefore enforced them to work on the inquiry task on a systematic basis, which resulted in more correct conclusions. A comparison between research of Eysink et al. (2015) and the specific guidance condition of the present research shows a similarity in the offered guidance to students: in both studies learners were presented with guidance structuring the learning process for learners. In either case, learners were told explicitly how an action should be performed. Gifted children seem to benefit from this explicit, specific guidance in working systematically on an inquiry task.

In contrast to the learning process, no significant differences between conditions were found on learning outcomes. This result was surprising, since it was predicted that a more effective learning process would lead to higher learning outcomes. An explanation could be found in the incommensurability between performance and learning, as explained by Kapur and Rummel (2012): evidence suggests that immediate performance and learning results are not as correlated as is often believed. In this study, the performance success of the specific guidance condition (more correct conclusions) did not lead to higher scores on the knowledge posttest. Guidance in the present study was directly aimed at improving the inquiry process of children and can therefore be less adequate in improving learning results on the short term. For future research, it would be interesting to investigate how to attain effects on the learning outcomes by tailoring the learning process.

As a consequence of the significant difference found in the learning process, specific guidance appears to be the most effective guidance type in supporting gifted children during inquiry learning. It could be concluded that the combination of scaffolds and explanations is more effective in supporting gifted children during inquiry learning than the combination of process constraints and status overviews or prompts and heuristics. This result resembles the meta-analysis conducted by Lazonder and Harmsen (2016), showing that learners generally benefit most from specific guidance. This finding apparently also applies to gifted children. The finding seems contradictory with the expertise reversal effect explained by Kalyuga (2007): providing experienced learners, with high prior knowledge and skills, with explicit guidance is likely to be counterproductive for performance. Due to a variety of skills and higher prior knowledge, it could be expected that gifted children are able to successfully perform an inquiry without much explicit guidance. However, it could be that the young gifted children participating in this study did not have much prior knowledge about the science domain electricity. This study was conducted with gifted children from grade three, four, five or six of elementary education. It would be interesting to investigate whether there are any age-related differences between these gifted children concerning effect of guidance, due to differences concerning prior knowledge and skills.

The second hypothesis stated that the experimental condition with the highest scores on learning process and learning outcomes also experienced the most flow. In this study, no significant effect of guidance was found on flow, so the hypothesis was not confirmed. Results did show that flow positively influenced conceptual knowledge acquisition and the learning process. So, the gifted children with the highest scores on learning outcomes and learning process also experienced the most flow. High scores on learning process and learning outcomes can be indicators of a balance between task complexity and skills. Therefore, the finding seem to be in line with Rea (2000), Clinkenbeard (2012), Johnsen (2009), and Csikszentmihalyi et al. (2005), all claiming that gifted learners are more likely to experience flow when there is balance between challenge and skill.

The third hypothesis predicted that children in the non-specific condition showed the most positive mood, since this condition satisfies gifted children's preference to self-manage their learning task. It was also predicted that gifted children in the specific guidance condition show the least positive mood. In this study, no significant effect was found between conditions on total mood. There was a significant difference in neutral mood, however, only visible in one of three measurement times. Looking at the reported mood of the gifted children, it is notable that the positive mood is reported the most by all three conditions. An explanation could be that the learning task, and the hands- on experimenting with the electricity set, is not very similar to everyday educational practice and therefore triggered a positive mood by learners of all conditions. In both present research as research of Eysink et al. (2015), offering guidance to gifted children during inquiry learning did not have an adverse effect on their mood.

This study contributes to the theory with the findings that gifted children's learning process is more effective when this guidance is specific, and that offering guidance to gifted children during inquiry learning will not necessarily be at the expense of gifted children's mood. These findings point to implications for practice. Educators should keep in mind that offering guidance during inquiry learning will not automatically be detrimental for gifted children's mood. In supporting these children's learning process during inquiry learning, educators should present them with specific guidance, helping structuring the learning process and therefore supporting the learners in working systematically during inquiry learning. This could be done by telling gifted children explicitly what actions should be performed. So, guidance has to go beyond giving reminders, suggestions and tips.

The present study provides relevant information on the effect of specificity of guidance on gifted children's inquiry learning and opportunities for further research were created focusing on this topic. First, this study used the framework of specificity of guidance from De Jong and Lazonder (2014) to examine the effects of specificity of guidance on gifted children's learning. The conditions in this research received a worksheet with two or three guidance types combined. Therefore, it is still unclear what the effects of each guidance type individually will be. It would be interesting to examine the effects of each guidance type of the framework from De Jong and Lazonder (2014) on gifted children during inquiry learning. Second, it was found in this study that gifted children receiving specific guidance draw more correct conclusions during the learning process. The number of correct conclusions drawn during inquiry learning does give some insight in the effectiveness of the learning process, but inquiry learning covers more aspects than drawing conclusions, such as hypotheses generation or setting up testable experiments. In order to gain a more reliable result on the effects of specificity of guidance on gifted children's learning process, future research should therefore focus more deeply on the effect of specificity of guidance on multiple aspects of gifted children's learning process. For example, it could be interesting to investigate whether specific guidance is also beneficial for hypothesis generation and conducting experiments.

Conclusion

The goal of the study was to examine the effects of specificity of guidance on gifted children's inquiry learning. Therefore, the following research question was posed: *What is the effect of the specificity of guidance on the learning process, learning outcomes, mood, and flow of gifted children during inquiry learning in science education?* Prior research had already shown that gifted children learn the most from inquiry learning when they receive guidance while experimenting. It was still unclear what type of guidance is most effective for these children. Results of this study showed that specific guidance , such as scaffolds and explanations, leads to more correct conclusions drawn during the learning task and therefore is most beneficial for supporting the learning process. However, it did not lead to higher conceptual knowledge acquisition in the short term. Also, it was found that offering specific guidance will not necessarily be at the expense of gifted children's mood. This implies that guidance offered to gifted children during inquiry learning should be specific, helping the learner with structuring the learning process. The guidance has to be explicit, and has to go beyond giving reminders, suggestions and tips. With these findings, this study contributes to the knowledge base needed to tailor inquiry learning to the learning needs of gifted children.

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Appendix A

Non-specific guidance worksheet

Werkblad elektriciteit

Naam:

Geboortedatum:

Geslacht: meisje/ jongen

Jij bent straks een echte onderzoeker! Je gaat onderzoeken hoe elektriciteit werkt. Je krijgt straks vijf onderzoeksvragen. De vijf onderzoeksvragen ga je beantwoorden door experimenten uit te voeren. De experimenten voer je uit met het materialensetje dat je krijgt. Werk door tot je 'einde' ziet staan.

Vraag 1 van de 5

Welke materialen heb je nodig om een lampje te laten branden?

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Probeer het lampje te laten branden door te experimenteren.

Je mag hier jouw antwoord opschrijven:

………
………
………
………
………
………

Vraag 2 van de 5

Wat is het verschil tussen een open stroomkring en een gesloten stroomkring?

Bij deze onderzoeksvraag ga je onderzoeken wat het verschil is tussen een open en een gesloten stroomkring. Gebruik de stroomkring die je gemaakt hebt bij onderzoeksvraag één. Onderzoek wat een open en een gesloten stroomkring is door te experimenteren.

Je mag hier jouw antwoord opschrijven:

………
………
………
………

………
………

Vraag 3 van de 5

<u>Hoe werkt een schakelaar?</u>

Bij deze onderzoeksvraag ga je onderzoeken hoe een schakelaar werkt. Gebruik de stroomkring die je gemaakt hebt. Onderzoek hoe een schakelaar werkt door te experimenteren.

Je mag hier jouw antwoord opschrijven:

………
………
………
………
………
………

Vraag 4 van de 5

<u>Welke materialen geleiden stroom (geleiders) en welke materialen niet (isolatoren)?</u>

Bij deze onderzoeksvraag ga je onderzoeken welke materialen stroom geleiden en welke niet. Gebruik de stroomkring en voorwerpen uit jouw etui en uit de klas. Onderzoek welke materialen stroom geleiden en welke niet door te experimenteren.

Je mag hier jouw antwoord opschrijven:

………
………
………
………
………
………

Vraag 5 van de 5

Heeft de hoeveelheid lampjes en batterijen invloed op de felheid van het licht?

Bij deze onderzoeksvraag ga je onderzoeken wat de invloed van de hoeveelheid lampjes en batterijen is op de felheid van het licht. Gebruik de stroomkring die je gemaakt heb. Onderzoek de invloed op het felheid van het licht door te experimenteren.

Je mag hier jouw antwoord opschrijven:

………
………
………
………
………
………

Einde

Appendix B

Average specific guidance worksheet

Werkblad elektriciteit

Naam:

Geboortedatum:

Geslacht: meisje/ jongen

Jij bent straks een echte onderzoeker! Je gaat onderzoeken hoe elektriciteit werkt. Je krijgt straks vijf onderzoeksvragen. De vijf onderzoeksvragen ga je beantwoorden door experimenten uit te voeren. De experimenten voer je uit met het materialensetje dat je krijgt. Werk door tot je 'einde' ziet staan.

Welke materialen heb je nodig om een lampje te laten branden?

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Maak eerst een voorspelling voordat je gaat experimenteren. Dus denk eerst goed na of je het materiaal nodig hebt.

Probeer het lampje te laten branden door te experimenteren. Bepaal of je een materiaal echt nodig hebt om het lampje te laten branden. Dit kun je doen door één materiaal per keer te verwijderen uit jouw stroomkring.

Tip: Denk eraan om de materialen die je nodig hebt op te schrijven!

Je mag hier jouw antwoord opschrijven:

……
……
……
……
……
……

Wat is het verschil tussen een open stroomkring en een gesloten stroomkring?

Bij deze onderzoeksvraag ga je onderzoeken wat het verschil is tussen een open en een gesloten stroomkring. Gebruik de stroomkring die je gemaakt hebt bij onderzoeksvraag één. Maak eerst een voorspelling voordat je gaat experimenteren. Dus denk eerst goed na wat het verschil zou kunnen zijn tussen een open en een gesloten stroomkring.

Onderzoek wat een open en een gesloten stroomkring is door te experimenteren. Bepaal of je een open of een gesloten stroomkring hebt. Dit kun je doen door een open of gesloten stroomkring te maken door het rode en zwarte draadje tegen elkaar te houden, of van elkaar los te houden.

Tip: Denk eraan om op te schrijven wat een open en wat een gesloten stroomkring is.

Je mag hier jouw antwoord opschrijven:

……
……
……
……
……
……

Hoe werkt een schakelaar?

Bij deze onderzoeksvraag ga je onderzoeken hoe een schakelaar werkt. Gebruik de stroomkring die je gemaakt hebt. Maak eerst een voorspelling voordat je gaat experimenteren. Dus bekijk de schakelaar eerst goed en voorspel hoe de schakelaar werkt.

Onderzoek hoe een schakelaar werkt door te experimenteren. Bekijk één voor één het effect van een open en een gesloten schakelaar. Dit kun je doen door de schakelaar toe te voegen in jouw stroomkring.

Tip: Denk eraan om op te schrijven wat er met de stroomkring gebeurt bij een open en gesloten schakelaar.

Je mag hier jouw antwoord opschrijven:

……
……
……
……
……
……

Welke materialen geleiden stroom (geleiders) en welke materialen niet (isolatoren)?

Bij deze onderzoeksvraag ga je onderzoeken welke materialen stroom geleiden en welke niet. Gebruik de stroomkring en voorwerpen uit jouw etui en uit de klas. Maak eerst een voorspelling voordat je gaat experimenteren. Dus bedenk bij elk voorwerp eerst of het stroom geleid of niet.

Onderzoek welke materialen stroom geleiden en welke niet door te experimenteren. Bepaal of de voorwerpen stroom geleiden of niet. Dit kun je doen door de voorwerpen één voor één toe te voegen in jouw stroomkring.

Tip: Denk eraan om op te schrijven welke materialen stroom geleiden en welke niet.

Je mag hier jouw antwoord opschrijven:

……
……
……
……

……

……

<u>Heeft de hoeveelheid lampjes en batterijen invloed op de felheid van het licht?</u>

Bij deze onderzoeksvraag ga je onderzoeken wat de invloed van de hoeveelheid lampjes en batterijen is op de felheid van het licht. Gebruik de stroomkring die je gemaakt heb. Maak eerst een voorspelling voordat je gaat experimenteren. Dus bedenk eerst wat de invloed is op de felheid van het licht als je een extra lampje of batterij toevoegt.

Onderzoek de invloed op het felheid van het licht door te experimenteren. Bepaal de invloed van de hoeveelheid lampjes en batterijen op de invloed van het felheid van het licht. Dit kun je doen door één voor één een extra batterij of lampje toe te voegen in jouw stroomkring.

Tip: Denk eraan om op te schrijven wat er met de felheid van het licht gebeurt als er meer lampjes of batterijen worden toegevoegd.

Je mag hier jouw antwoord opschrijven:

……

……

……

……

……

……

Einde

Appendix C

Specific guidance worksheet

Werkblad elektriciteit

Naam:

Geboortedatum:

Geslacht: meisje/ jongen

Jij bent straks een echte onderzoeker! Je gaat onderzoeken hoe elektriciteit werkt. Je krijgt straks vijf onderzoeksvragen. De vijf onderzoeksvragen ga je beantwoorden door experimenten uit te voeren. De experimenten voer je uit met het materialensetje dat je krijgt.

Welke materialen heb je nodig om een lampje te laten branden?

Om een lampje te laten branden heb je elektriciteit nodig. Elektriciteit haal je uit een elektriciteitsbron. Dit kan de dynamo van jouw fietslamp zijn, een batterij, of de elektriciteitscentrale die stroom naar onze stopcontacten duwt. De elektriciteit moet vervolgens van de elektriciteitsbron naar het lampje kunnen stromen.

Bij deze onderzoeksvraag ga je onderzoeken welke materialen je nodig hebt om het lampje te laten branden. Gebruik het materialensetje dat je gekregen hebt. Probeer nu het lampje te laten branden door te experimenteren.

Nu het lampje brandt, ga je bepalen of je de materialen écht nodig hebt om het lampje te laten branden. Doe het als volgt:

Voorspellen		**Experimenteren**		**Concluderen**
Denk goed na. Wat denk je dat er gaat gebeuren als je het materiaal weghaalt uit de stroomkring?	⇨	Haal het materiaal weg uit de stroomkring en kijk goed wat er gebeurt.	⇨	Bepaal of je het materiaal nodig hebt om het lampje te laten branden.

Doe dit nu één voor één met alle materialen. Vul het volgende schema in:

Onderdelen	**Voorspelling**	**Conclusie**
Grondplaten	Wel/niet nodig	Wel/niet nodig
Verbindingsstukjes	Wel/niet nodig	Wel/niet nodig
Batterij(en)	Wel/niet nodig	Wel/ niet nodig
Rode draden	Wel/niet nodig	Wel/ niet nodig

Zwarte draden	Wel/niet nodig	Wel/ niet nodig
Lampjes	Wel/niet nodig	Wel/ niet nodig
Schakelaar	Wel/niet nodig	Wel/niet nodig

Wat is het verschil tussen een open stroomkring en een gesloten stroomkring?

Wat je zojuist bij vraag 1 gemaakt hebt heet een stroomkring. Een stroomkring is een circuit van kabels, batterijen, apparaten en schakelaars. Om apparaten die aangesloten zijn in de stroomkring te laten werken moet de elektriciteit van de ene naar de andere kant van de elektriciteitsbron kunnen stromen. Vandaar de naam: stroomkring.

Bij deze onderzoeksvraag ga je onderzoeken wat het verschil is tussen een open stroomkring en een gesloten stroomkring. Gebruik de stroomkring die je gemaakt hebt bij onderzoeksvraag één.

Als eerste ga je onderzoeken wat er gebeurt als je het rode en zwarte draadje van elkaar los haalt. Doe het als volgt:

Voorspellen		**Experimenteren**		**Concluderen**
Denk goed na. Wat denk je dat er gaat gebeuren als je het rode en zwarte draadje van elkaar los haalt?	→	Haal het rode en zwarte draadje los van elkaar en kijk goed wat er gebeurt.	→	Bepaal of je een open of een gesloten stroomkring hebt.

Onderzoek nu op dezelfde manier wat er gebeurt als het rode en het zwarte draadje elkaar wel raken. Vul het volgende schema in:

	Voorspelling Wat denk ik dat er gaat gebeuren?	**Experimenteren** Wat zie ik dat er gebeurt?	**Conclusie** Is het een open of een gesloten stroomkring?
Het rode en zwarte draadje raken elkaar niet			
Het rode en zwarte draadje raken elkaar			

Hoe werkt een schakelaar?

Een schakelaar kan toegevoegd worden aan een stroomkring. Een schakelaar heeft twee standen: een open en een gesloten stand.

Bij deze onderzoeksvraag ga je onderzoeken hoe een schakelaar werkt. Gebruik de stroomkring die je gemaakt hebt.

Als eerste ga je onderzoeken wat er gebeurt als je de schakelaar met een gesloten stand toevoegt in een stroomkring. Doe het als volgt:

Voorspellen	→	**Experimenteren**	→	**Concluderen**
Denk goed na. Wat denk je dat er gaat gebeuren als je de schakelaar met gesloten stand toevoegt in een stroomkring?		Geef de schakelaar een plek in jouw stroomkring. Kijk goed wat er gebeurt.		Bepaal wat er gebeurt met de stroomkring als je een gesloten schakelaar toevoegt.

Doe dit nu ook met een open schakelaar. Vul het onderstaande schema in:

	Voorspelling Wat denk ik dat er gaat gebeuren?	**Experimenteren** Wat zie ik dat er gebeurt?	**Conclusie** Wat gebeurt er met de stroomkring?
Gesloten schakelaar			
Open schakelaar			

<u>Welke materialen geleiden stroom (geleiders) en welke materialen niet (isolators)?</u>

Elektriciteit kan door sommige materialen beter stromen dan door andere. Materialen waar elektriciteit makkelijk doorheen stroomt worden geleiders genoemd. Materialen waar elektriciteit minder makkelijk, of zelfs helemaal niet door kan stromen worden isolators genoemd.

Bij deze onderzoeksvraag ga je onderzoeken welke materialen stroom geleiden en welke materialen niet. Gebruik de stroomkring die je gemaakt hebt.

Als eerste ga je onderzoeken of jouw potlood een geleider of een isolator is. Doe het als volgt:

Voorspellen		**Experimenteren**		**Concluderen**
Denk goed na. Van welk materiaal is het voorwerp gemaakt? Zou het een geleider of een isolator zijn?	→	Geef het voorwerp een plek in jouw stroomkring. Kijk goed wat er gebeurt.	→	Bepaal of het voorwerp een geleider of een isolator is.

Doe dit nu ook met verschillende voorwerpen uit jouw etui. Vul het volgende schema in:

Voorwerp	**Van welk materiaal is het voorwerp gemaakt?**	**Voorspelling**	**Conclusie**
Potlood		Geleider/ isolator	Geleider/ isolator
Schaar		Geleider/ isolator	Geleider/isolator
Puntenslijper		Geleider/isolator	Geleider/isolator
………………… (eigen keuze)		Geleider/isolator	Geleider/isolator
…………………. (eigen keuze)		Geleider/ isolator	Geleider/ isolator
Deze materialen zijn geleiders:			

Deze materialen zijn isolators:

Heeft de hoeveelheid lampjes en batterijen invloed op de felheid van het licht?

Een stroomkring kan meerdere batterijen en/of meerdere lampjes bevatten.

Bij deze onderzoeksvraag ga je onderzoeken wat de invloed is van de hoeveelheid lampjes en batterijen op de felheid van het licht. Gebruik de stroomkring die je gemaakt hebt.

Als eerste ga je onderzoeken wat er gebeurt als je 2 lampjes en 1 batterij in een stroomkring hebt. Doe het als volgt:

Voorspellen	**Experimenteren**	**Concluderen**
Denk goed na. Wat denk je dat er gaat gebeuren met de felheid van het licht?	Pas jouw stroomkring aan, voeg de extra lampjes of batterijen toe.	Bepaal wat de invloed is op de felheid van het licht.

Doe dit nu ook met 1 lampje en 2 batterijen in de stroomkring, en met 2 lampjes en 2 batterijen. Vul het onderstaande schema in:

	Voorspelling Wat denk ik dat er gaat gebeuren?	**Experimenteren** Wat zie ik dat er gebeurt?	**Conclusie** Wat is de invloed op de felheid van het licht?
2 lampjes en 1 batterij			
1 lampje en 2 batterijen			

2 lampjes en 2 batterijen			

Einde

Appendix D

Answer sheet pretest

Vraagnummer	Aantal te verdienen punten (totaal: 22)	Verdeling aantal punten	Correcte antwoorden	Verdere toelichting
1	2	Voor elk goed antwoord wordt 1 punt toegekend	Elk apparaat dat elektriciteit gebruikt. *Bijvoorbeeld:* elektrische tandenborstel, telefoon, tv, elektrisch speelgoed	-
2	2	Punt 1: omcirkelen van het goede antwoord	**Niet**	-
		Punt 2: geven van een goede uitleg	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -er een draadje loszit -er geen sprake is van een gesloten stroomkring -de draadjes elkaar niet raken -het niet met elkaar verbonden is	
3	2	Voor een goed antwoord wordt 1 punt toegekend	Elk apparaat dat een batterij gebruikt. *Bijvoorbeeld:* afstandsbediening, elektrische (speelgoed)auto, rekenmachine	
4	5	Voor elk woord dat op de juiste plek is ingevuld wordt 1 punt toegekend.	Goede plek van de woorden: Plek 1: de klas/ huis Plek 2: huis/ de klas Plek 3: schakelaar Plek 4: stroom Plek 5: stroomkring	
5	1	Voor het juiste antwoord wordt 1 punt toegekend	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -de draden zitten los -er is geen sprake van een gesloten stroomkring	Antwoorden die hetzelfde zijn of lijken op de volgende worden niet goed gerekend: -de lamp is kapot -de lamp is niet aangesloten op de stroom
6	2	Punt 1: omcirkelen van	**Wel**	-

		het goede antwoord		
		Punt 2: geven van een goede uitleg	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -alle draden elkaar raken -er sprake is van een gesloten stroomkring -de stroom kan stromen -ijzer geleidt stroom	Uit het antwoord moet blijken dat ijzer stroom geleidt, of er moet uit het antwoord blijken dat het kind begrijpt dat alle onderdelen met elkaar verbonden moeten zijn. Antwoorden die hetzelfde zijn of lijken op de volgende worden niet goed gerekend: - het zit aangesloten.
7	2	Punt 1: omcirkelen van het goede antwoord	**Niet**	
		Punt 2: geven van een goede uitleg	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -hout geen stroom geleidt -elektriciteit niet door hout heen kan -hout geen geleider is	
8	3	Voor omcirkelen van het goede antwoord/ doorstrepen van het foute antwoord wordt steeds 1 punt toegekend.	Vraag 1. Omcirkelen: nee En/ of doorstrepen: ja Vraag 2. Omcirkelen: ja En/ of doorstrepen: nee Vraag 3: Omcirkelen: nee En/ of doorstrepen: ja	
9	1	Voor het juiste antwoord wordt 1 punt toegekend	Een antwoord wordt goed gerekend als er twee lijnen getekend zijn, één van het lampje naar de plus en een ander van het lampje naar de min	
10	1	Voor het juiste antwoord wordt 1 punt	Antwoorden die hetzelfde zijn of lijken op de volgende	

		toegekend	worden goed gerekend: -het licht gaat feller branden -het licht gaat harder branden	
11	1	Voor het juiste antwoord wordt 1 punt toegekend	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -het licht gaat feller branden -het licht gaat harder branden	

Appendix E

Answer sheet posttest

Vraagnummer	Aantal te verdienen punten (totaal: 40)	Verdeling aantal punten	Correcte antwoorden	Verdere toelichting
1	3	Vraag 1a. Punt 1, 2: voor elk goed antwoord wordt 1 punt toegekend	Elk apparaat dat elektriciteit gebruikt. *Bijvoorbeeld:* elektrische tandenborstel, telefoon, tv, elektrisch speelgoed	-
		Vraag 1b. Punt 3: geven van het goede antwoord	Elk voorbeeld van een stroomkring in huis. *Bijvoorbeeld:* bij de lamp, bij de tv, bij de magnetron, bij een stopcontact.	-
2	5	Punt 1: het geven van het goede antwoord	**Nee**	-
		Punt 2 t/m 5: het gebruik van 1 van de 4 woorden in de goede context levert een punt op.	Antwoorden waarbij de woorden **open, gesloten, stromen, stroomkring** in een goede zin/ context worden gebruikt worden goed gerekend. *Bijvoorbeeld:* Het lampje gaat niet branden, omdat het geen gesloten maar een open stroomkring is. De stroom kan daardoor niet stromen.	
3	1	Voor een goed antwoord wordt 1 punt toegekend	Elk apparaat dat een batterij gebruikt. *Bijvoorbeeld:* afstandsbediening, elektrische (speelgoed)auto, rekenmachine	
4	13	Vraag 4a. Punt 1 t/m 5: voor elk woord dat op de juiste plek is ingevuld wordt 1 punt toegekend	Goede plek van de woorden: Plek 1: de klas of het huis Plek 2: huis of de klas Plek 3: schakelaar Plek 4: stroom Plek 5: stroomkring	
		Vraag 4b. Punt 6 t/m 13: voor elk goed woord dat	Plek 1: stroomkring, draden, batterij, lampje (4 punten)	

		ingevuld is wordt 1 punt toegekend	Plek 2: stroomkring of geleider Plek 3: isolatoren Plek 4: schakelaar Plek 5: *Bijvoorbeeld:* lichtknopje, waterkoker, koffiezetapparaat (1 punt)	
5	1	Voor het juiste antwoord wordt 1 punt toegekend	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -de draden zitten los -er is geen sprake van een gesloten stroomkring	Antwoorden die hetzelfde zijn of lijken op de volgende worden niet goed gerekend: -de lamp is kapot -de lamp is niet aangesloten op de stroom
6	4	Vraag 6a. Punt 1: omcirkelen van het goede antwoord	**Wel**	-
		Vraag 6a. Punt 2: geven van een goede uitleg	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -alle draden elkaar raken -er sprake is van een gesloten stroomkring -de stroom kan stromen -ijzer geleidt stroom	Uit het antwoord moet blijken dat ijzer stroom geleidt, of er moet uit het antwoord blijken dat het kind begrijpt dat alle onderdelen met elkaar verbonden moeten zijn. Antwoorden die hetzelfde zijn of lijken op de volgende worden niet goed gerekend: - het zit aangesloten.
		Vraag 6b. Punt 3: omcirkelen van het goede antwoord	**Geleider**	
		Vraag 6b. Punt 4: geven van een goed voorbeeld	Alle materialen die geleiden. *Bijvoorbeeld:* goud/ zilver/ koper/ koolstof/ grafiet/ metaal	
7	4	Vraag 7a. Punt 1: omcirkelen van het goede antwoord	**Niet**	

		Vraag 7a. Punt 2: geven van een goede uitleg	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: -hout geen stroom geleidt -elektriciteit niet door hout heen kan -hout geen geleider is	
		Vraag 7b. Punt 3: omcirkelen van het goede antwoord	**Isolator**	
		Vraag 7b. Punt 4: geven van een goed voorbeeld	Alle materialen die isoleren. *Bijvoorbeeld:* papier, rubber.	
8	6	Punt 1, 2, 3: voor het omcirkelen van het goede antwoord/ doorstrepen van het foute antwoord wordt elke keer 1 punt toegekend	Vraag 1. Omcirkelen: nee En/ of doorstrepen: ja Vraag 2. Omcirkelen: ja En/ of doorstrepen: nee Vraag 3. Omcirkelen: nee En/ of doorstrepen: ja	
		Punt 4, 5, 6: Voor het geven van een goede uitleg wordt elke keer 1 punt toegekend.	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed gerekend: Vraag 1 en 3: -Het is een open stroomkring -de draden zijn niet met de plus en min verbonden Vraag 2: -het is een gesloten stroomkring -de plus en de min zijn verbonden.	
9	1	Voor het juiste antwoord wordt 1 punt toegekend	Een antwoord wordt goed gerekend als er twee lijnen getekend zijn, één van het lampje naar de plus en een ander van het lampje naar de min	
10	1	Voor het juiste antwoord wordt 1 punt toegekend	Antwoorden die hetzelfde zijn of lijken op de volgende worden goed	

			gerekend: -het licht gaat feller branden -het licht gaat harder branden	
11	1	Voor het juiste antwoord wordt 1 punt toegekend	**Ja.**	

Appendix F

Flow short scale

Wat vond je van deze taak?

	Klopt					Klopt niet	
Ik vind de opdrachten leuk	1	2	3	4	5	6	7
Ik vind het fijn dat je bij deze opdrachten nieuwe dingen leert	1	2	3	4	5	6	7
Deze opdrachten vind ik nuttig	1	2	3	4	5	6	7
Ik hoef geen beloning. De opdrachten gaven me plezier genoeg!	1	2	3	4	5	6	7
Deze opdrachten vond ik erg interessant	1	2	3	4	5	6	7
Denken ging makkelijk	1	2	3	4	5	6	7
De juiste gedachten kwamen vanzelf	1	2	3	4	5	6	7
Bij iedere opdracht wist ik wat ik moest doen	1	2	3	4	5	6	7
Ik had het gevoel dat ik alles onder controle had	1	2	3	4	5	6	7

Appendix G

Mood measurement

Tijd: _______________

Hoe voel je je over deze taak?

Appendix H

Answer sheet learning process analysis

Taak nummer	Aantal te verdienen punten (max. 1, geen halve punten)	Beoordelingscriteria
1	1	In de conclusie moeten in ieder geval de volgende materialen genoemd worden: **batterij, draden, lampje.** In het geval er een extra materiaal genoemd wordt, wordt hier geen aftrek van punten op gegeven. Indien er meer dan 1 extra materiaal genoemd wordt, worden er geen punten toegekend.
2	1	De conclusie moet dit antwoord of een vergelijkbaar antwoord bevatten: Bij een open stroomkring worden de volgende antwoorden goed gerekend: -Als twee draadjes elkaar niet raken/ niet alle materialen verbonden zijn is er sprake van een open stroomkring. -Bij een open stroomkring brandt het lampje niet -Bij een open stroomkring kan de stroom niet stromen Bij een gesloten stroomkring worden de volgende antwoorden goed gerekend: -Als twee draadjes elkaar wel raken/ alle materialen verbonden zijn is er sprake van een gesloten stroomkring. -Bij een gesloten stroomkring brandt het lampje wel -Bij een gesloten stroomkring kan de stroom stromen
3	1	De conclusie moet dit antwoord of een vergelijkbaar antwoord bevatten: -Bij een gesloten shakelaar is er sprake van een gesloten stroomkring/ het lampje brandt/ de stroom kan stromen. -Bij een open schakelaar is er sprake van een open

		stroomkring/ de stroom kan niet stromen/ het lampje brandt niet.
4	1	In de conclusie moet in ieder geval 1 materiaal genoemd worden dat geen stroom geleidt, en 1 materiaal dat stroom geleidt. Alleen het benoemen van een voorwerp zonder het materiaal erbij te vermelden wordt niet goed gerekend.
5	1	In de conclusie moet duidelijk verwoord worden dat de hoeveelheid lampjes en batterijen invloed heeft op de felheid van het licht. Antwoorden die hetzelfde zijn/ lijken op de volgende worden goed gerekend: -Als er meer batterijen toegevoegd worden wordt het licht feller -Als er meer lampjes toegevoegd worden, wordt het licht minder fel