Using the Metacognition and Reflective Inquiry Method as a Metacognitive Stimulant for Gifted Students

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Abstract

Gifted students who underachieve or even dropout of education represent a valuable loss for society and an unrealized personal fulfillment. In literature many solutions are offered to tackle this problem, they all pursue the development of metacognition. Many students indicate that they do not perceive the usefulness of metacognition and fail to motivate themselves. The current study investigates the so-called metacognitive reflective inquiry (MRI) method (Anderson, Nashon and Thomas, 2009) as a potential tool to make gifted students aware of the usefulness of metacognition. Based on a procedure consisting of a pre-interview, followed by a specially designed project and a post-interview aimed at reflection, students showed more awareness of the usefulness of metacognition. Nevertheless, there was no control group, and only five participating students. Therefore, no firm general conclusions may be drawn.

Introduction

Gifted underachieving students sometimes lack self-efficacy, goal-directedness and self-regulation skills (Clark, 1988; Emerick, 1992; Siegle & McCoach 2002; Van Boxtel & Monks, 1992). These traits are all relevant parts of metacognition and metacognition is again correlated to the academic achievements of students (Young & Fry, 2012). When gifted students underachieve due to a lack of metacognitive knowledge and skills, they might eventually also dropout of education (Reis & McCoach, 2000). This dropout is a very relevant problem since those students represent a loss of valuable human resources, as well an unrealized fulfillment of the individual.

Hattie (2009) investigated the effectiveness of different teaching approaches in a comprehensive meta-analysis. From his study, it became clear that one of the most effective teaching approaches is to emphasize the use of metacognitive strategies and self-regulated learning by students. Other studies such as the ones by Schraw and Graham (2010) and Veenman and Elshout (1992) also emphasize the importance of metacognition for gifted students.

Current education for gifted students already includes many different methods to trigger the use of metacognitive strategies by gifted students and to develop their metacognitive knowledge. The study by Zohar and Barzilai (2013) summarizes these methods. In order of frequency of use these are: metacognitive prompts, reflective writing, practice and training, teacher led metacognitive discussions, student led metacognitive discussions, explicit instruction, ICT use for metacognitive instruction, concept mapping and other visual representations and metacognitive modeling by the teacher. Even though gifted students are instructed to use those practices, they often fail to do so. This is due to a lack of motivation because they do not see any benefit from the use and development of

metacognitive strategies (Stichting Leerplan Ontwikkeling [SLO], 2005; Martin, Mintzes & Clavijo, 2000).

Learning of natural sciences happens most effectively when students see learning as a kind of knowledge restructuring and continuously seek to find relationships and connections between existing and new knowledge (Martin et al., 2000). This is also why successful learners (experts) in natural sciences excel in self-awareness and the ability to monitor, regulate and control their own learning (Chi, Glazer & Farr, 1988; Martin et al., 2000).

Teaching in natural sciences aims at developing those skills using inquiry based learning (IBL). IBL also provides teachers with the possibility to differentiate and to challenge gifted students to use higher cognitive processes and to develop more complex products (Gallagher & Gallagher, 1994). This differentiation is very important since gifted students have high cognitive capacities and outperform typical students. By presenting them to a project, which challenges them, they might perceive the need to develop metacognitive skills.

This paper will adopt the definition of metacognition as defined by Zohar and Barzilai (2013) who based their definition on a review of research and on the leading figures such as Flavell, Miller, and Miller (2002) and Efklides (2006), Veenman, van Hout-Wolters, and Afflerbach (2006). According to their definition, metacognition is composed of three components. The first component is metacognitive knowledge; this refers to acquired knowledge of persons (including knowledge about self), tasks and strategies. The second is metacognitive skills, which refers to knowledge about skills, such as planning, evaluating and metacognitive processes. The third part is the metacognitive experiences, which can be both affective and cognitive and are related to a task.

The study performed by Anderson, Nashon and Thomas (2009) was aimed at resolving the illusive nature and character of metacognition, to do so they performed the so-called metacognition and reflective inquiry (MRI) method. One of their main findings was that participants found the experience of being interviewed about their stage one involvement: "an experience from which they learnt about themselves as learners and how they might alter their strategies and their knowledge construction" (p. 191). These experience about self-awareness and the monitoring, regulation and controlling of knowledge are important parts of metacognition for gifted students. Especially during the learning process of natural sciences.

The current study investigates the usefulness of the MRI method as developed by Anderson, Nashon and Thomas (2009), to make gifted students aware of the importance of the use and development of metacognitive skills and knowledge in natural sciences. The MRI method consists of three phases. In the first phase, the students participate in a specially designed project for gifted students, during the second phase they will individually reflect upon themselves, and in the third phase, a group reflection will take place.

The project of phase 1 is specially developed for the gifted students to make them use metacognitive skills and is based on a couple of guidelines, as established by Anderson, Nashon and Thomas (2009). These guidelines include that there should be an opportunity for the gifted students to personally engage in higher order thinking, creativity and metacognition. Higher order thinking involves evaluation and creation as defined by Bloom. Creativity can be enhanced by removal of any limits and expectations. The use of metacognition can be triggered by a very high workload, which forces the students for example to use a planning.

In stage two, the recorded material is used for individual reflection, to stimulate personal recall of metacognitive activities. In addition, the last phase is a semi-structured

interview with the whole group. During this phase, the interview is used to recall and reflect on the use of metacognitive activities by the whole group.

The aim of this study is to determine how we can enhance the awareness of metacognition by gifted students using the MRI method. We want to see how participating in a specially developed project for gifted students to challenge those students to use metacognition followed by personal and group reflection on metacognition affects the awareness of metacognition by gifted students. This can be formulated in the following research question: What are the effects of the MRI method on the awareness of metacognition by gifted students?

This research question is divided in two sub questions, namely:

1. What do gifted students learn about the usefulness of metacognition when they participate in the metacognitive reflective inquiry method?
2. To what extent can this specially designed project as developed in this study challenge students to use metacognition?

Method

This study evaluates the efficacy of the MRI method to develop metacognitive awareness in gifted students, using a pretest-intervention-posttest design. The intervention consists of participation in a special project in which the MRI method will be used. Tests will address metacognitive skills and knowledge. In addition, an achievement motivation test was administered, because giftedness is often associated to high achievement and motivation in literature (Gangé, 2004).

Setting and Participants

Five students (all female) with an average age of 13.4 years (M=13.4, SD=0.48, Min=13, Max=14) were involved in this study. The students all attended to the same academic high school namely Corlaer College. The students were in their first or second year of secondary education.

Gifted status was determined by the school in consultation with teachers of primary education, parents and cito-vas scores. The cito-vas scores provide insight into how the student scores on core competences like proficiency, numeracy and vocabulary it also shows the strengths and weaknesses of the students.

Measures and Procedures

All students completed the achievement motivation test, which resulted in a score on achievement, negative and positive failure anxiety and social desirability (Heller, 1999). The score on social desirable answers are taken into account when evaluating the pre- and post-interview data.

Pre (semi-structured) interview

Students were interviewed about their existing knowledge of metacognition. The interview questions were based on the metacognitive awareness inventory (MAI). The MAI was developed by Schraw and Denisson (1994) to evaluate metacognitive knowledge and regulation. It consists of 52 statements (appendix 2) concerning the existing knowledge of metacognition and metacognitive skills. Those two categories include the same subcategories as the definition of Zohar and Barzilai (2013) which is used in this study. The pre-interview topic list can be found in appendix 4.

Intervention

After the pre-interview two groups are formed consisting of three and two students. Each group includes one student who scores high on metacognition based on the pre-interview. In each group, there is also a student with more previous knowledge concerning phase one bee project. This is important so the students are triggered to learn from one another, which results in cooperative learning, and peer-learning.

Phase one "bee-project"

During phase one the students participated in a specially developed project. During this project the students worked together to criticize an old model of what a bee would see, next they had to develop a new model, and last they had to develop an experiment to support their newly developed model (Appendix 3). This developed project contained as little as possible guidelines and limits, to stimulate creativity, it had to be performed in two hours, to create a high workload and the students had to create a new model to participate in higher order cognition. Further, the students had to base their criticism on literature, which they could find via the internet or in books, they also had to support their line of reasoning by arguments. This project is based on the guidelines as described in the introduction and during this phase all students were video recorded.

Phase 2 individual

During phase two, students individually looked back at their own performance during phase one. The participants were asked to pause the film when they saw themselves or another participant using or talking about metacognition. At the beginning, they also received a description and explanation of metacognition. This phase is important for students to be acquainted with viewing themselves.

Phase three, group (semi-structured) interview

During phase three, the groups from phase one are interviewed about their use during phase one of metacognition. Specific film fragments which were selected according to the criteria described below, where shown. During those film fragments, the students had to tell why those fragments were selected considering metacognition. During this phase there was also a semi-structured interview, which was used to trigger a discussion about the metacognitive processes used during the project of stage one (Anderson et al. 2009). The semi-structured interview contained open and closed questions. A sample item of the semi-structured interview question (Appendix 1) was: "what key things stick in your mind from your experiences in the group activity?" These questions together with video excerpts facilitated an open-ended discussion about the metacognitive development, awareness and usefulness.

Selection criteria for video selection

The following criteria were used to select video fragments for phase three recall (Anderson et al, 2009). Those criteria are indicative of metacognitive use and are used as probes to stimulate discussions about metacognition.

- Incidents that appear indicative for the deployment of metacognitive strategies
- Moment in which the participants evaluate their self knowledge
- Self selection of learning strategy
- Evaluation of that strategy
- Cognitive struggles or impasses by which the group members need to reflect deeply on their knowledge and problem solving strategies, which were fertile ground for deeper levels of metacognition
- Incidents that were considered indicative of individuals engagement of higher order thinking skills

Data analysis

Student's answers from the pre-interview and phase three interview where transcribed using express scribe transcription software and labeled using N-vivo. Every student answer was labeled according to the schema depicted in table 1, which is based on the definition of metacognition as defined by Zohar and Barzilai (2013)

Table 1. Description of the codes used for the analysis of students answers. The first column shows the categories of the labels, the second column shows the code and the third column shows the description of the label.

Category	Code	Description
Declarative knowledge	DK	Knowledge about one's skills intellectual resources and abilities as a learner
Procedural knowledge	PK	Knowledge about how to implement learning procedures (e.g. strategies)
Conditional knowledge	CK	Knowledge about when and why to use learning procedures
Planning	P	Planning, goal setting, and allocating resources prior to learning
Information management strategies	IM	Skills and strategy sequences used on-line to process information more efficiently
Monitoring	M	Assessment of one's learning or strategy use

Debugging	D	Strategies used to correct comprehension and performance errors
Evaluation	E	Analysis of performance and strategy effectiveness after a learning episode

Every label was also positively or negatively labeled. When a student could not argument why she for example used a planning, or gave a positive answer but with an argumentation which had nothing to do with the answer, or said that she did not understood the question and even after clarifying the meaning could not give an answer to the question it was negatively labeled. This resulted in a positive and negative score for each label. Every student was asked about each label a couple of times, so when a student never scored on a specific label or only negatively then it was possible to conclude that this person had no knowledge about that specific part of metacognition.

A second rater, who analyzed three out of five interviews, verified this label schema. The inter-rater reliability was good, Cohen's kappa was 0.67.

The analysis of the pre-interview data was performed by analyzing:

1. The number of times that a student talks positively about a category,
2. The number of times that a student talks (positive and negative) about a category,
3. The number of times that a student is asked to talk about a category,
4. The number of times that a student answers to a question in a total different category, compared to the intention of the question.

By comparing the amount of times a student talks positively about a certain category (1) and the amount of times a student talks positive and negative about a category (2) a ratio can be calculated from which can be concluded whether or not a student has knowledge of this category. For example, when a student spoke six times positively about conditional knowledge and spoke six times about this category, it means that the student receives an overall ratio of 1 and has knowledge about conditional knowledge. This resulted in the category ‘pre-interview high score’, as can be seen in table 3. In this category, only ratios of 1 are mentioned.

All students scored during the pre-interview at least several times positive on all categories of metacognition, this is because the students were asked to think about all categories. In table 3 only the labels of metacognition with a 100% positive score where shown in the category pre-interview score.

The next category of table 3 is the ‘pre-interview low score’, this category summarizes the categories on which a student scores only a positive label in one third of their answers. This indicates a relative low amount of knowledge of this category, since a negative label indicates that the student could not come up with an argument for her answer, or answered with “I don’t know”.

The third category is the ‘lack of understanding during pre interview’. The labels that are mentioned in this category are not understood by the student when asked about this category, the student answered in a different category.

The last category is ‘post-interview scores’. The labels in this category are the labels, which are positively mentioned by the student during post-interview of phase 3. All categories are mentioned about which the participants spoke positively and the bold ones are mentioned most often. During the post-interview students were only prompted to think about the

different labels of metacognition and asked to talk about it in a more general sense. This resulted in less comments compared to the pre-interview on all labels.

Results

In this section, we combine quantitative data of the pre- and post-interview labels with the qualitative analysis of the statements, which were made by the participating students during the pre- and post-interview about their perceived usefulness of metacognition.

Achievement motivation test

The student's scores for the achievement motivation test are depicted in table 2. The achievement motivation test scored on four different categories. Namely achievement motivation (P), negative (F-) and positive (F+) failure anxiety and social desirable answers (Sw). Student two and four score high on social desirability, which indicates that they have the intention to give socially desirable answers and they want to meet the expectations of the environment. Especially the qualitative data of those students should be regarded with suspicion since those answers might be socially desirable (Hermans, 1983).

The last column of table two shows the education advice of the participating students which is based on cito-vas scores, elementary school teachers and students motivation.

Table 2. The achievement motivation test scores from the participating gifted students. The following symbols have the following meaning ± = average; + = above average; - = below average; - - = strongly below average. The four scales are abbreviated to characters and they stand for: P achievement, F+ and F- respectively positive and negative failure anxiety and Sw social desirability.

	Achievement motivation test		Education
Student 1	P 21; ±	F+ 9; ±	VWO advice
	F- 3; -	Sw 11; ±	
Student 2	P 17; ±	F+ 6; ±	VWO advice
	F- 8; ±	Sw 17; +	

Student 3	P 9; -	F+ 5; ±	HAVO/VWO advice, underachievement at the moment
	F- 10;±	Sw 10; ±	
Student 4	P 18; ±	F+ 7; ±	VWO advice
	F- 6; ±	Sw 18; +	
Student 5	P 25; +	F+ 12;+	Gymnasium advice
	F- 2; --	Sw 15; ±	

Pre-interview scores

From the pre-interview data, it can be seen that students do have metacognitive knowledge. Student five scores very high on five out of eight subcategories of metacognition. Indicating a high amount of metacognitive knowledge. She also scores high during post-interview on metacognitive knowledge and talks about five out of eight subcategories of metacognition.

Student two on the contrary scores low on metacognition. During the pre-interview student two never received a ratio of one, which means student two never answered all questions of one category positively. This indicates that the knowledge of metacognition was very low. Student two also scored very low on procedural knowledge and planning. Compared to the post-interview were planning, declarative knowledge and procedural knowledge, was labeled positive. This indicates that student two learnt about metacognitive knowledge.

Student four is an excellent student and scores high on procedural knowledge, debugging strategies and IM during the pre-interview. Student four also understood al questions and never scored low on one of the categories. During the post-interview student

four even mentioned six out of eight categories of metacognition, indicating a large amount of knowledge of metacognition.

Student three shows a high score on debugging strategies and a low score on declarative knowledge. During the pre-interview student three also lacks understanding of declarative knowledge and monitoring. During the post-interview, on the other hand student three scores the highest score on declarative knowledge indicating that student three learnt about metacognition.

Student one shows a high score on conditional knowledge and debugging strategies, and scores low on IM. During the pre-interview student one lacks understanding of evaluation and planning for a couple times but during the post-interview she positively mentions both categories. This indicates that student one learnt about metacognition.

Student five scores high during the pre-interview on five out of eight categories and did not have a low score. Student five did however, fount procedural knowledge a difficult subject, during the pre-interview student five talked a lot about metacognition. Student five did not need much questioning or probing since she spoke extensively about her knowledge of metacognition but when asked about specifically procedural knowledge she sometimes answered in a different category, indicating that she might not be aware of the meaning of procedural knowledge.

Table 3. Pre- and post-interview awareness of metacognition.

	Pre-interview score	Pre-interview low score	Lack of understanding during pre-interview (amount of times)	Post-interview **(highest)** score
Student 1	Conditional knowledge Debugging strategies.	IM	Evaluation (4) and planning (3)	**Declarative knowledge,** procedural knowledge, planning, IM, evaluation monitoring

Student 2	There was no 100% positive score. The best score was for conditional knowledge.	Procedural knowledge, planning	Conditional knowledge (3), declarative knowledge(1), IM (4)	**Planning** Declarative knowledge, procedural knowledge,
Student 3	Debugging strategy	Declarative knowledge	Declarative knowledge (2), monitoring (3)	**Declarative knowledge,** procedural knowledge, evaluation, IM, planning.
Student 4	Procedural knowledge, debugging, IM	-	-	**Declarative knowledge,** conditional knowledge, procedural knowledge, evaluation, IM, planning.
Student 5	Procedural knowledge, debugging strategy, Declarative knowledge, planning, IM.	-	Procedural knowledge (3)	**Declarative knowledge,** conditional knowledge, procedural knowledge, IM, planning.

Note: IM stands for Information management.

Pre- and post-interview qualitative data

Student 1

During the pre-interview student 1 made some remarkable statements about her own knowledge of metacognition. After a couple of questions about knowledge of cognition, the student was asked about the use of learning strategies. She declares in the first instance that she does not use learning strategies, than she remembers some specific cases during which she did use a strategy. All quotes are translated from Dutch to English.

Student 1: No, eehh.. However, when there is something very difficult I try to write it down in a schema or in chronological order like with history, but most of the times I do not use learning strategies.

Later on when she was asked to think of some specific school subjects in combination with learning strategies she recalls even more cases in which she uses learning strategies.

Student 1: The words I need to know I print for myself and then I read them and when I don't know the words I shade them and those are the ones I need to repeat until I know them.

Student1: For German words I use the program WRTS, and I write my own summary and glossary.

During the pre-interview, she becomes aware of her learning strategies and the way she gains her knowledge.

The pre-interview data were also compared to the post-data. This student scores during the pre-interview low on IM, while during the post-interview she positively mentions IM as can be seen in table 3. She also lacks knowledge about evaluation and planning a couple of times during the pre-interview while during the post-interview she talks positively about those two categories.

During the post-interviews, stages three of the MRI method, all students were asked to tell what they thought they had learnt during this project and if they thought it was useful. Student 1 declares that she gained consciousness about her own use of metacognitive skills due to this project.

Student 1: ..Yes, I think I can better apply my metacognitive kills than before, because I am aware of its usefulness and the way I already use it. I have seen myself using it so I understand it now.

Student 1 also gained knowledge about herself as a learner. She specifically mentions that she saw herself many times sharing information with fellow students when asked or not,

and that she realizes now when she is doing this, so she can control herself. The last thing she mentions is that she realizes that she uses different strategies, like evaluation and monitoring, she gained this awareness according to herself due to the self reflection. This is also in line with the pre- and post-interview comparison, where she talks more positive during the post interview about metacognitive skills compared to the pre-interview.

Student 1: I also realize the strategies I use now, because we had to reflect upon this when we watched ourselves. For example I realize when I am evaluating my knowledge, and this is a good thing to do in real life, and to realize what everyone knows and thinks about the subject, and the next step would be to evaluate our strategies. This is important to know from one another to cooperate effectively.

During the post-interviews, all students were also asked whether they had ever thought about this kind of thinking (thinking about thinking). Only student 1 commented on this question the other students answered with “no”. She noticed that a couple of years ago she had followed a lecture about metacognition and back then she already thought that it was useful, but she had forgotten about this. Through this project, she realizes this usefulness again and indicates that she can use it now in daily life. This indicates that student 1 perceived the usefulness of metacognition after the MRI method, and could argument why she perceived the usefulness of this project. This student was a motivated student who stood open for feedback, and eagerly participated in this project. From the achievement motivation test comes clear that she has no socially desirable tendency in answering the questions.

Student 2.

Student 2 indicates only in one case that this project might have been beneficial for her. She indicates that she learnt about metacognitive skills and specifically about the

usefulness of planning. This student was less motivated to participate in this project, and scores high on the social desirability score as can be seen in table 2. This indicates that her answers might not be as positive as they might seem.

Student 3.

Student 3 indicates during the post-interview that she learnt about herself as a learner. She saw herself using some creative ideas and did not think about herself as being a learner who does these kinds of things.

Student 3: Well, I have seen that I use a different kind of learning than I thought, for example with that telephone, I did not expect myself to think like that, I couldn't even remember myself doing that, I really like it.

During phase 1 student three realized at one point that a bee's sight is different from human because they do not see red, but they do see UV light. On the internet, it was described as seeing total different colors, which made the student hypothesize that a bee might see reversed colors, which she wanted to show using a telephone app. This is a very creative expression.

Student 3 scores during the achievement motivation test very low on achievement, which indicates that this student has little motivation for anything related to school. During the post-interview she also indicates that she did not learn much about the bee's because she had no desire to learn about this subject. Next year she will also be participating in HAVO instead of VWO.

Student 4.

Student 4 declares that metacognition might be useful, but not for her, she indicates like student 1 that the MRI method is beneficial in gaining knowledge about self and

metacognition. She did not really need to change her way of studying or learning, because she is already performing very well, so for her personally there are no actual needs to participate in this kind of projects.

Student 4: It can certainly be useful, I think, when students do not know for example how or where to start, or when something goes wrong during the learning process, and when you want to reflect upon this by yourself it will not work, and you will not come to those insights we have gained during this project. Students might see themselves making mistakes during planning or with something else, this might be useful in this case because you can adjust your way of working. However, for myself I have not learnt much because I am satisfied with the way I learn.

Student 4 was an active participant during this project she even showed initiative for next appointments and was positively involved during the project. She was also very curious about her performance during this study. She might however give social desirable answers as concluded from the achievement motivation test, here she does however state that she personally did not gained or perceived any personal gains. Indicating that she is not influenced by social desirability.

Student 5.

Student 5 like student 1 learnt about herself as a learner. This student was eager to talk and showed during the project many creative thoughts, which often distracted her from the task at hand. She mentioned many concepts, which had nothing to do with the bee-project. During the post-interview she reflects upon this by concluding that she needs a more goal directed partner to work with and she also mentions a couple of times that she is often distracted and that she is aware of her own distractedness, and needs to change this behavior.

During this study student 5 became aware of the different learning strategies she uses and about her own creativity.

Student 5 : I understand now that I'm a very creative person in my thoughts, I connect many concepts. I also understand that I need a more goal directed partner to work with. I have also learnt about the learning strategies I use.

Student 5 was also a motivated student who wanted to achieve, this is also congruent with the achievement motivation test.

Bee-project

The group consisting of three students used a planning, in which they wrote down all the aspects they wanted to investigate at the beginning and wrote their name behind the part they were responsible for. To prevent themselves from forgetting things. Both groups also negotiated about who will be doing what, they used arguments like, "I am good at writing an introduction" or "I'm not very good at drawing and creative stuff". This indicates that they were aware of their own skills and how to make use of this.

During the project both groups but especially the group consisting of two students used thinking out-loud by themselves. During the post-interview they were asked for the reason they were doing this, they came up with the following arguments: "to inform one another of their findings, to get acquainted with the difficult and new knowledge and to remember and elaborate their knowledge". This indicates that the students were evaluating and monitoring their knowledge in an active manner. During the project both groups also discussed the possibilities of gaining new insights, since information about bee vision is scares on the internet. They discussed different strategies like, you-tube movies, blogs, books and so on. Therefore, they were well aware of the different strategies they could use to acquire new information.

Groups

Based on the pre-interview the students were grouped for phase one the “bee project”. The students were divided in two groups, one group consisting of three students and one group of two students. The students were assigned to a group depending on foreknowledge of metacognition. Foreknowledge of metacognition was analyzed using the pre-interview. This indicated that that student five and four had the most metacognitive knowledge. Group 1 consisted of students five, one and two. Group 2 consisted of student three and four.

Conclusion

The aim of this study was to determine how we can enhance the awareness of metacognition by gifted students using the MRI method. This was achieved by using the MRI method as developed by Anderson, Nashon and Thomas (2009) followed by an analysis of student’s pre- and post- interview answers.

Understanding of metacognition

The change in students understanding of metacognition was investigated by comparing students answers in pre- and post-interviews, and by questioning the participating students about their understanding. Since there were only five participating students there was no statistical analysis possible, only a qualitative analysis.

The MRI method contributed in the understanding of metacognition of the five participating students. When student answers of the pre-interview are compared to the post interview it can be seen that the categories mentioned under low score are also positively mentioned during the post-interview. Also are all categories, which are mentioned under lack of understanding listed in the post interview scores. This indicates that the students have learnt about those subcategories of metacognition during the project.

All students have positively mentioned declarative knowledge during the post-interview and all except one had the highest score on declarative knowledge during the post interview. All students gained insight in their own skills, intellectual resources and abilities as a learner, and understood the meaning of declarative knowledge at the end of this project.

During the pre-interview, all students mention positively the debugging strategy, this is not mentioned any more during the post-interview. This indicates that students do have knowledge about this category when asked specifically about this part of metacognition, but when the students are only prompted or implicitly asked to talk about this subject they are not inclined to talk or even think about this. This indicates that students are not conscious about their use of debugging strategies.

Perceived usefulness of metacognition

During the post-interview all students were asked to tell what they thought was useful during this project. Student answers ranged from very positive like student one, to a perceived usefulness but not for themselves like student four. The other students mentioned that they gained insight into their own learning process due to this project. Those students do mention that they have learned something by participating in this project but do not explicitly link this to the development of metacognition.

Specially designed project

The bee-project triggered the use of metacognition by the participating gifted students, since they used a planning, and started to reason about the usefulness of different strategies to gain knowledge. They also actively monitored their progress and evaluated their knowledge and the way they gained their knowledge. These are all very relevant parts of metacognition.

Based on these conclusions it is save to conclude that the MRI method is a promising method to enhance the awareness of metacognition by gifted students. Still it is important to do more quantitative research to support this conclusion.

Discussion

This study indicates that the MRI method might be a useful tool to achieve this but there are some critical notes to discuss, that will be done in this part.

One of the main questions is whether the effects caused by the MRI method are really due to the intervention, since all students participated in the pre-interview in which they were asked to think about their use and knowledge of metacognition. This resulted in a learning effect for student one. Therefore, the pre-interview might also be a useful tool to create awareness of metacognition.

There was no control group, and only five participating students. This means that no firm, general conclusions may be drawn attributing the learning observed to the intervention. In addition, during the project not all phases of the MRI method were followed as quickly as desirable, group two finished the group reflection two weeks after the bee-project. Group 1 consisted of three persons during the bee-project but due to sickness during the third phase, which included group reflection and the post interview, was performed with only two students and later on independently with the third student.

Student one has followed a lecture about metacognition before this project this might have influenced her learning trajectory. Since she has learnt about this subject earlier and has preliminary knowledge, even though she is not aware of this knowledge anymore as she indicated during the pre-interview.

A follow-up study in which students are followed for a longer period of time to see whether students really profit by their gained knowledge about self and metacognition. By monitoring their progress to so see lasting changes in strategy use, for example student 2 indicated that she wanted to elaborate her planning skills and wanted to use this more often. It might also be interesting to investigating whether the MRI approach can benefit typically developing students as well.

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Appendix 1 semi structured interview

Group Interview Protocol: Stage 3

1. What key things stick in your mind from your experiences in the group activity?

2. What new understandings did you gain from the experience in the group activity?

3. How did you find the task of listening to yourself and reflecting on what was said?

4. What did you learn about your own thinking from hearing yourself? What did you learn?

5. Have you ever thought about this type of thinking before?

6. Could you identify any incidences where you felt you became aware of your own knowledge (physics knowledge)?

7. Can you recall any incidence where you put your knowledge to work?

8. Were you asking yourself questions? Were you talking to yourself when you were _x_? What were you talking about? What kinds of questions were you asking yourself?

9. Why did you ask yourself these questions?

10. Why did you use that kind of thinking?

11. What do you know about your own thinking?

12. Did you have a plan?

13. VIDEO—Critical Incidents (Stage 2)

14. Were you aware of the other group members' learning? What learning?

15. Can you tell me what the most important thing that you've told me today?

Appendix 2 MAI questionnaire

Metacognitive Awareness Inventory (MAI)

Check True or False as appropriate. Use the Scoring Guide after completing the inventory.

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		
3. I try to use strategies that have worked in the past.		
4. I pace myself while learning in order to have enough time.		
5. I understand my intellectual strengths and weaknesses.		
6. I think about what I really need to learn before I begin a task		
7. I know how well I did once I finish a test.		
8. I set specific goals before I begin a task.		
9. I slow down when I encounter important information.		
10. I know what kind of information is most important to learn.		
11. I ask myself if I have considered all options when solving a problem.		
12. I am good at organizing information.		
13. I consciously focus my attention on important information.		
14. I have a specific purpose for each strategy I use.		
15. I learn best when I know something about the topic.		

16. I know what the teacher expects me to learn.		
17. I am good at remembering information.		
18. I use different learning strategies depending on the situation.		
19. I ask myself if there was an easier way to do things after I finish a task.		
20. I have control over how well I learn.		
21. I periodically review to help me understand important relationships.		
22. I ask myself questions about the material before I begin.		
23. I think of several ways to solve a problem and choose the best one.		
24. I summarize what I've learned after I finish.		
25. I ask others for help when I don't understand something.		
26. I can motivate myself to learn when I need to		
27. I am aware of what strategies I use when I study.		
28. I find myself analyzing the usefulness of strategies while I study.		
29. I use my intellectual strengths to compensate for my weaknesses.		
30. I focus on the meaning and significance of new information.		
31. I create my own examples to make information more meaningful.		
32. I am a good judge of how well I understand something.		
33. I find myself using helpful learning strategies automatically.		
34. I find myself pausing regularly to check my comprehension.		
	True	Fals

35. I know when each strategy I use will be most effective.		
36. I ask myself how well I accomplish my goals once I'm finished.		
37. I draw pictures or diagrams to help me understand while learning.		
38. I ask myself if I have considered all options after I solve a problem.		
39. I try to translate new information into my own words.		
40. I change strategies when I fail to understand.		
41. I use the organizational structure of the text to help me learn.		
42. I read instructions carefully before I begin a task.		
43. I ask myself if what I'm reading is related to what I already know.		
44. I reevaluate my assumptions when I get confused.		
45. I organize my time to best accomplish my goals.		
46. I learn more when I am interested in the topic.		
47. I try to break studying down into smaller steps.		
48. I focus on overall meaning rather than specifics.		
49. I ask myself questions about how well I am doing while I am learning something new.		
50. I ask myself if I learned as much as I could have once I finish a task.		
51. I stop and go back over new information that is not clear.		
52. I stop and reread when I get confused.		

Metacognitive Awareness Inventory (MAI) Scoring Guide

Directions -- For each True on the MAI give yourself 1 point on the following charts. For each False, give yourself 0 points in the Score column. Total the score of each category and place in box.

KNOWLEDGE ABOUT COGNITION

DECLARATIVE KNOWLEDGE	**DECLARATIVE KNOWLEDGE**	SCORE
– The factual knowledge the learner needs before being able to process or use critical thinking related to the topic – Knowing *about, what, or that* – Knowledge of one's skills, intellectual resources, and abilities as a learner – Students can obtain knowledge through presentations, demonstrations, discussions **PROCEDURAL KNOWLEDGE** – The application of knowledge for the purposes of completing a procedure or process – Knowledge about *how* to implement learning procedures (e.g. strategies) – Requires students know the process as well as when to apply process in various situations – Students can obtain knowledge through discovery, cooperative learning, and problem solving **CONDITIONAL KNOWLEDGE** – The determination under what circumstances specific processes or skills should transfer – Knowledge about *when* and *why* to use learning procedures – Application of declarative and procedural knowledge with certain conditions presented – Students can obtain knowledge through simulation	5. I understand my intellectual strengths and weaknesses.	
	10. I know what kind of information is most important to learn.	
	12. I am good at organizing information.	
	16. I know what the teacher expects me to learn.	
	17. I am good at remembering information.	
	20. I have control over how well I learn.	
	32. I am a good judge of how well I understand something.	
	46. I learn more when I am interested in the topic.	
	TOTAL	/8

PROCEDURAL KNOWLEDGE	SCORE	**CONDITIONAL KNOWLEDGE**	SCORE
3. I try to use strategies that have worked in the past.		15. I learn best when I know something about the topic.	
14. I have a specific purpose for each strategy I use.		18. I use different learning strategies depending on the situation.	
27. I am aware of what strategies I use when I study.		26. I can motivate myself to learn when I need to.	
33. I find myself using helpful learning strategies automatically.		29. I use my intellectual strengths to compensate for my weaknesses.	
		35. I know when each strategy I use will be most effective.	
TOTAL	/4	TOTAL	/5

REGULATION OF COGNITION

PLANNING –Planning, goal setting, and allocating resources *prior* to learning **INFORMATION MANAGEMENT STRATEGIES** –Skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing) **COMPREHENSION MONITORING** –Assessment of one's learning or strategy use **DEBUGGING STRATEGIES** –Strategies used to correct comprehension and performance errors **EVALUATION** –Analysis of performance and strategy effectiveness after a learning episode	**PLANNING**	SCORE
	4. I pace myself while learning in order to have enough time.	
	6. I think about what I really need to learn before I begin a task.	
	8. I set specific goals before I begin a task.	
	22. I ask myself questions about the material before I begin.	
	23. I think of several ways to solve a problem and choose the best one.	
	42. I read instructions carefully before I begin a task.	
	45. I organize my time to best accomplish my goals.	
	TOTAL	7

INFORMATION MANAGEMENT STRATEGIES	SCORE	**COMPREHENSION MONITORING**	SCORE
9. I slow down when I encounter important information.		1. I ask myself periodically if I am meeting my goals.	
13. I consciously focus my attention on important information.		2. I consider several alternatives to a problem before I answer.	
30. I focus on the meaning and significance of new information.		11. I ask myself if I have considered all options when solving a problem.	
31. I create my own examples to make information more meaningful.		21. I periodically review to help me understand important relationships.	
37. I draw pictures or diagrams to help me understand while learning.		28. I find myself analyzing the usefulness of strategies while I study.	
39. I try to translate new information into my own words.		34. I find myself pausing regularly to check my comprehension.	
41. I use the organizational structure of the text to help me learn		49. I ask myself questions about how well I am doing while learning something new.	
43. I ask myself if what I'm reading is related to what I already know.			
47. I try to break studying down into smaller steps.			
48. I focus on overall meaning rather than specifics.			
TOTAL	10	TOTAL	7

DEBUGGING STRATEGIES	SCORE	**EVALUATION**	SCORE
25. I ask others for help when I don't understand something.		7. I know how well I did once I finish a test.	
40. I change strategies when I fail to understand.		18. I ask myself if there was an easier way to do things after I finish a task.	
44. I re-evaluate my assumptions when I get confused.		24. I summarize what I've learned after I finish.	
51. I stop and go back over new information that is not clear.		36. I ask myself how well I accomplish my goals once I'm finished.	
52. I stop and reread when I get confused.		38. I ask myself if I have considered all options after I solve a problem.	
		49. I ask myself if I learned as much as I could have once I finish a task.	
TOTAL	5	TOTAL	6

Appendix 3 “bee project”

Inhoudsopgave

Inhoud

Docentenhandleiding

Groepsindeling

We maken twee groepen. (1 groep van 2 en 1 groep van 3)
In elk groep zit iemand die de module psychologie deel 1 doorlopen heeft en 1 persoon die de module creatief met kleur doorlopen heeft. Groepjes zijn vooraf samengesteld op basis van pre interviews over metacognitieve vaardigheden, zodat peer learning kan plaats vinden.

Instructies voor de leerlingen

Jullie krijgen zo meteen als groep een opdracht die je gaat uitvoeren binnen de twee lesuren die we voor dit project hebben. Er wordt veel van jullie gevraagd dus bedenk van te voren goed hoe jullie alles gaan doen, en welke informatie je nodig hebt, hoe en waar je dat vandaan gaat halen, als ook wie wat gaat doen.

Dit betekent ook dat jullie enkel de tijd hebben tijdens deze twee project uren, niet hierbuiten.

Het gaat niet alleen om de oplossing of om het nieuw bedachte model maar het gaat ook om het proces hiernaartoe, dus de gebruikte creativiteit, de manier van modelpresentatie, de onderbouwing en het gebruikte wetenschappelijke materiaal.

De hoofdvraag bestaat uit twee delen, een “wat” en een “hoe” vraag. Beide moeten beantwoord worden. Met de “hoe vraag” kijk je vanuit verschillende wetenschappelijke kanten naar de werking van het bijenoog. Op basis van deze kennis ga je vervolgens de “wat vraag” beantwoorden, namelijk een echt beeld creëren van wat een bij volgens jullie ziet. Dit mag je volledig zelf weergeven, wees creatief.

Daarnaast schrijf je een plan voor het onderzoek waarmee je data gaat verzamelen om jouw model te onderbouwen.

Interventies

De onderstaande interventies dient u als docent in te zetten wanneer:
- Leerlingen na 20 minuten nog steeds geen idee hebben over wat zij moeten gaan doen.
- Leerlingen na 1 les uur blijven haken op 1 onderdeel of te weinig onderzoeken.

beginnen met verschillende brillen te kijken naar het probleem dus:
- *Gedragsmatig***,** je wilt honing dus zul je bloemen veel beter moeten kunnen onderscheiden van de achtergrond.

- *Psychologisch***,** onderzoeken of bepaalde bloemen meer bijen trekt dan andere bloemen waardoor je kunt afleiden of bepaalde kleuren beter zichtbaar zijn.

- *Natuurkundig***,** bijen hebben 3 soorten kegeltjes twee zelfde als de mens alleen de rode niet en een extra in het uv gebied, uv zicht en patronen op planten zien bijen dus wel. Wij zien uit de basis drie kleuren, maar onze hersenen verwerken dit tot een geheel beeld met een spektakel aan kleuren. Bijen hebben geen rood maar wel uv, wat voor zicht zal dit geven (denken als een bijenbrein met een mensen brein).

- *Fysiologisch*, bijen hebben facet ogen en ocelli dus drie oogjes op het hoofd, de ocelli hebben een andere functie in het zicht van bijen in vergelijking met het facet oog. Het facet oog zorgt voor het composiet, maar hoe verwerkt het brein dit? Bijen reageren heel goed op beweging.

- *Biologisch*, co-evolutie tussen bijen en planten, steeds verdere ontwikkeling van bijenoog en plant diversiteit (voornamelijk in het onzichtbare spectrum voor de mens UV).

Verantwoording

Creativiteit: zelf bedenken wat het model moet zijn, weinig tot geen kaders, creativiteitstest.

Planmatig werken: te veel om maar gewoon wat te doen, samen werken moet en afstemmen wie wat doet.

Samenwerking: verschillende voorkennis dus elkaar vanuit verschillende hoeken ondersteunen in kennis

Peer learning: uit onderzoek komt naar voren dat in groepjes werken, waarbij er verschil zit tussen metacognitieve vaardigheden, de leerlingen van elkaar leren, één van de meest efficiënte methodes om metacognitieve vaardigheden bij te brengen. Uit het interview worden 2 leerlingen gedestilleerd met meer metacognitieve vaardigheden waarvan 1 in elk groepje geplaatst wordt.

Relevante domein kennis: relevante domein kennis is bij minimaal 1 per groep aanwezig, kennis van kegeltjes, staafjes enz. relevante domein kennis is belangrijk voor een setting waarbij strategieën voor probleem oplossen moet plaats vinden.

Higher cognitief engagement: het bekritiseren en ontwerpen van een model, plus bijna onmogelijke taak.

motivatie: pmtk test en engagement in dit project is vrijwillig.

Wat zien bijen?

Project van 2 x 50 minuten.

Tijdens dit project ga je onderzoeken wat een bij ziet. Dit project vraagt om creativiteit en is een uitdaging om zelf op onderzoek uit te gaan en je kennis te vergroten op het gebied van biologie, natuurkunde, psychologie en natuurwetenschappelijk onderzoek. Het wetenschappelijke model wat jullie gaan bekritiseren laat zien wat men lang dacht dat een bij zou zien, hier ga je vervolgens, een ander/beter/ creatiever en/of mooier model tegenover plaatsen en onderbouwen.

Aan het einde van deze twee lessen ben je in staat om:

- Een model met wetenschappelijke kennis kritisch te bediscussiëren
- Zelf een model te ontwerpen op basis van wetenschappelijke informatie
- Zelf een onderzoek op te zetten om je eigen model te ondersteunen

Het model

Mensen hebben in hun oog verschillende zintuigen namelijk kegels en staafjes. Hiermee kunnen we kijken. Bijen zien met dezelfde soort zintuigen. Een groot verschil met het menselijke oog is dat bijen een facet oog hebben. Wetenschappers hebben een model gemaakt van wat een bij zou moeten “zien” en zijn tot het volgende beeld gekomen.

Figuur 1. Links is wat een mens ziet en rechts hetzelfde beeld zoals een bij het volgens het wetenschappelijke model ziet.

Het linker beeld van figuur 1 is wat wij mensen zien,volgens de wetenschap ziet een bij ditzelfde beeld maar dan zoals je op het rechter plaatje kunt zien. Dit mozaïekpatroon is volgens het model een gevolg van het facetoog. Je kunt je afvragen of bijen werkelijk zo zien als op het rechterplaatje, of dat er nog andere mogelijkheden zijn.

Nu gaan jullie kritisch kijken naar dit model. Dit kun je vanuit verschillende invalshoeken doen. Bijvoorbeeld vanuit een gedragsmatige of psychologische invalshoek. Waarschijnlijk zijn er veel meer invalshoeken waardoor je kunt kijken naar dit probleem. Probeer hier zoveel mogelijk van te bedenken en vanuit elke invalshoek naar het model te kijken om zo kritisch mogelijk te zijn. Vervolgens

onderbouw je dit vanuit de wetenschappelijke literatuur en je eigen gedachten hierover.

Tijdens het project gaan jullie dit model uit de wetenschap bekritiseren en zelf een beeld creëren van wat een bij volgens jullie ziet. Dit beeld onderbouw je met informatie uit wetenschappelijke bronnen. Vervolgens schrijven jullie een plan voor een onderzoek, om een deel van je model of het gehele model te onderzoeken via een wetenschappelijke methode.

Analyseer tijdens het project de betrouwbaarheid van je bronnen en noteer deze in een literatuurlijst.

Appendix 4. pre-interview topic list.

Topic list interview

Introductie

- Interview over metacognitieve vaardigheden
    - Wat voor kennis je hier zelf al van hebt
    - Welke onderdelen je mogelijk bewust/onbewust al gebruikt
    - Wat voor waarde je aan deze onderdelen hecht
- Bedankt voor het mee doen
    - Resultaten zullen anoniem worden verwerkt, en eventueel worden uitspraken gebruikt in het artikel die niet naar jou als persoon te herleiden zijn.
- Toestemming voor gebruik van opnameapparatuur
    - Interview opnemen op die manier kan ik beter luisteren en minder te schrijven, als ik het opnameapparaat heb opgestart zal ik eerst jou naam noemen en de datum vervolgens nog een keer aan jou vragen of het goed is dat ik dit gebruik.
- Vragen? start.

Interview

Zegt het woord metacognitieve vaardigheden jou iets? En zo ja wat? En waarvan?

Metacognitieve vaardigheden uitleg. Kennis van cognitie en regulatie van cognitie.

Beginnen met kennis van cognitie.

1. Als eerst gaan we kijken naar jouw kennis over je eigen intellectuele mogelijkheden als leerling, en je eigen vaardigheden als leerling.

Kun jij vertellen wat jouw sterke en zwakke punten zijn op het gebied van leren? (stampen, logica, hoofd en bijzaken, organiseren van info, mate van begrip meten)

Onder welke omstandigheden kun jij het meest optimaal presteren voor een toets of juist voor het leren? En waarom?

2. We gaan het nu hebben over leerstrategieën.

Heb jij bepaalde leerstrategieën?

Kun je een voorbeeld geven en uitleggen waarom dit voor jou werkt?

Hoe ga je om met leerstrategieën, je hebt bijvoorbeeld een nuttige leerstrategie gevonden en blijf je deze dan gebruiken of wissel je af? En waarom?

3. We gaan het nu hebben over de conditionele kennis, dus over onder welke condities je bepaalde strategieën gebruikt, of onder welke condities enzovoort.

Je had het over ….. als leer strategie, is dit alleen effectief bij dat ene vak?

Kun je van jezelf benoemen of je een zwak punt benoemd onder 1 op een bepaalde manier compenseert? Hoe? En bewust?

Kun jij jezelf motiveren om te gaan leren als je hier totaal geen zin in hebt? En heb je daar een specifieke manier voor?

We gaan het nu hebben over de tweede categorie.

1. Het reguleren van cognitie, dus bijvoorbeeld planmatig werken, doe je dit zelf ook of heb je bepaalde routines bij het leren?

Maak je afspraken met jezelf over tempo, tijd, wat je wel en wat je niet leest/leert, of je een bepaalde strategie wel of niet gaat gebruiken?

Waarom en kun je een voorbeeld geven?

2. De volgende categorie gaat over het managen van informatie. Controleer je tijdens het leren of je leerproces en strategie gebruik effectief is en goed gaat?

Dus tijdens het leren neem bijvoorbeeld biologie kom je een moeilijk stuk tegen wat doe je dan? (vertragen in lezen of 2 keer over lezen, vertalen in eigen woorden?)

Kun je meer van dit soort voorbeelden benoemen die jij gebruikt?

Wat werkt het beste voor jou? En waarom?

3. Nu gaan we het hebben over het bijhouden van je eigen kennis, dus hou jij tijdens het leren voor jezelf bij wat je weet en of je bijvoorbeeld genoeg weet om een voldoende te halen voor de repetitie?

En hoe doe je dat, en hoevaak?

Kijk je ook wel eens terug naar wat je geleerd hebt en of je dit nu begrijpt? Hoe vaak doe je dit? En kun je een voorbeeld geven?

4. Wanneer je merkt dat je iets niet begrijpt of verkeerd hebt aangeleerd wat doe je dan?

Wat doe je zodra je merkt dat je ergens van in de war raakt, dus dingen door elkaar hebt zitten in je hoofd.

5. Na het leren van een bepaald iets, voor een bepaald vak kijk je dan ook wel eens terug naar hoe je dit gedaan hebt?

Kun je een voorbeeld noemen?

Anders moeten leren/minder moeten leren/meer moeten leren/was de leer methode effectief?

Appendix 5

Planning

phase	duration	Major research focus	Classroom events	Research methods employed
design	1 week	Developing high cognitive activities and group activities in which metacognition needs to be used by the whole group.	No classroom interventions.	MAI questionnaire, and creativity and motivation questionnaire.
1	4 weeks	Investigate the influence of the intervention (developed project) on students metacognition and learning processes.	Using the developed high cognitive activities in class during project.	Videotaping of classroom and individual students during project.
2	2 weeks	Monitor and investigate students conscious use of metacognition.	Outside the classroom, face to face interview.	Videotaped recall of the use of metacognition by individual students.
3	2 weeks	Identify changes in students perception of metacognition	Group interview concerning the	Semi-structured group interview

		and the use of it.	use of metacognition by the whole group.	with previously selected videotaped material to search for metacognitive use by the participating students.