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Problem-solving strategies and giftedness

A study into observable differences in problem-solving strategies between gifted and non-gifted children

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Abstract

Research shows differences in several problem-solving skills between gifted and regular students. This study investigated whether a clear distinction could be made between gifted and regular children by observing the actions performed while solving a problem. 25 regular and 22 gifted primary school students were given the same problem from the game 'laser maze'. Gifted children showed more investigative behaviour before having to solve a problem which was directly related to finding the solution faster. No other difference between gifted and regular children was found. Using a Latent Class Analysis (LCA), the results showed a difference between behaviourally active and behaviourally passive students. More research into different problem-solving styles is suggested. Time spent planning showed no difference between groups and more research into the concept of planning and how to measure it is suggested.

Samenvatting

Onderzoek laat op het gebied van probleem oplossen verschillen in vaardigheden zien tussen hoogbegaafde en reguliere kinderen. In dit onderzoek werd onderzocht of er een duidelijke scheiding te ontdekken was tussen de observeerbare acties van hoogbegaafde en van reguliere kinderen. 25 reguliere en 22 hoogbegaafde basisschoolleerlingen kregen eenzelfde probleem van het spel 'laser maze'. De resultaten lieten zien dat de hoogbegaafde kinderen meer onderzoekend gedrag toonden in de periode voor het probleem opgelost moest worden. Dit gedrag was direct verbonden aan een snellere oplostijd. Geen andere significante verschillen waren gevonden. Verder liet een latente klasse analyse (LCA) een onderscheid zien tussen gedragsmatig actieve en gedragsmatig passieve studenten. Meer onderzoek naar verschillende probleem-oplos stijlen wordt geadviseerd. De tijd die aan het plannen besteed wordt liet geen significant verschil tussen de groepen zien en meer onderzoek naar het concept van plannen en hoe dit gemeten kan worden wordt geadviseerd.

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Introduction

An abundance of research into the topic of giftedness can be found, yet there is still controversy around the definition of giftedness and there are area’s left undiscovered. It has been suggested that gifted students think and work in a qualitatively different way compared to regular students (Dai, 2009; Winner, 2000). However, more research on this topic is needed to confirm this hypothesis. Encouraging gifted children to think in their own unique way is important. The development of their talents could lead to unique accomplishments in adulthood which could benefit our whole society (Gallagher, 2015).

Most researchers seem to agree on the notion that the environment plays a crucial role in the development of giftedness (Miller, 2012; Perleth & Wilde, 2009; Sternberg & Grigorenko, 2002; Stoeger, 2009). Education is an important part of this environment that can either stimulate or discourage growth of gifted abilities. Research shows that one of the biggest problems in education faced by gifted children is underachievement. Guldemond, Bosker, Kuyper, and Van der Werf (2007) did a cohort study in which they tracked the educational achievements of gifted students for three years starting from the average age of 12. The researchers compared the achievement results to the level these children were expected to have based on IQ-tests. The researchers calculated that approximately 18% of the gifted children performed below the expected achievement level in reading and 15% in mathematics.

Another problem is noted by Davidson (2009). He reports that most of the children recognized as gifted do not grow up to become eminent in a certain field. So somewhere along the way to adulthood, most of the gifted children seem to lose their gifted potential. He also explains that a better understanding of what giftedness is, and how to recognize it, is needed before we can start to improve the imbalance between gifted children and eminent adults. More insight into the difference between gifted and regular students and the acceptance thereof could help the educational system adapt to the needs of the gifted students (Van Tassel-Baska & Stambaugh, 2005). This insight could be used to improve the instruction method used with gifted children, because this method needs to match the learning style and way of thinking of the student (Gagne & Wager, 2002). Students should learn through instruction and assessment how they can identify their strengths and compensate for their weaknesses (Sternberg & Grigorenko, 2002). Research shows that gifted students are better problem solvers than regular students (Steiner, 2006). Problem solving is also one of the most important cognitive skills in general as well as in education (Frederiksen, 1984). The aim of this study is to investigate the differences between gifted and regular children in the problem-solving domain.

Giftedness

Having above average intelligence or a high IQ is generally associated with giftedness (Sternberg, 2004). However, there is still a lot of debate about how giftedness can be defined. Renzulli (2000) defines giftedness as an interaction between three traits: above average intelligence, high levels of task commitment, and high levels of creativity. In comparing different studies, Renzulli concluded that high levels of creativity require higher levels of intelligence but from an IQ of 120 or higher the interaction with task commitment also plays a fundamental role in creativity. Thus, all three traits have to be present and interacting with each other in order for a person to be called gifted according to this theory. Renzulli does not give a definition of creativity, which has been criticised by some. However, it allows a certain flexibility in defining creativity (Miller, 2012). Creativity is measured in several different ways in research, but it is generally seen as indispensable to giftedness (Miller, 2012; Hui, Wu-Jing He, & Suk Ching Liu, 2013; Saunders Wickes & Ward, 2009). Gifted students are generally described as curious and highly motivated to learn when correctly stimulated (Perleth & Wilde, 2009; Sternberg, 2004; Winner, 2000). This internal drive to learn and master new things results in gifted students making their own discoveries and often self-educate (Winner, 2000).

Neurological studies seem to support the argument that being gifted means thinking in a qualitatively different way (Geake, 2009). Geake gives an overview of several neurological studies performed with gifted children. These studies show that gifted children develop a much denser level of grey matter which is related to being able to store more knowledge and a rapid processing of information. Research also shows that gifted children have heightened activation in the prefrontal brain area which is related to higher levels of abstract and creative thinking. Another benefit of the heightened activation in this area is that gifted students are better at knowing what steps to take when solving a problem. This heightened activation and denser grey matter could be associated to gifted students being fundamentally better at solving complex problems (Steiner, 2006).

Problem solving

Duncker (1945) (as cited in Robertson, 2005) provides an extensive definition of a problem:

> A problem arises when a living creature has a goal but does not know how this goal is to be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there is recourse to thinking… Such thinking has the task of

> devising some action which may mediate between the existing and the desired situations. (p. 1)

Thus, a problem only exists when it is not immediately clear how to get from the current state to a desired goal state. When this discrepancy between states is established, a problem-solving strategy can be used to get to the solution (Gick, 1986). There are three basic components connected to problem solving: metacognition, knowledge acquisition, and performance. (Siegler & Alibali, 2005). Metacognition involves the activation and directing of the other components. In the knowledge acquisition component, information is gathered and processed about the problem. Performance involves the physical actions taken to solve a problem. These components each have their own type of strategy: metacognitive strategies, cognitive strategy, and performance strategies respectively.

Metacognition

Research has shown considerable differences between gifted and regular children when it comes to metacognition (Snyder, Nietfeld, & Linnenbrink-Garcia, 2011). The metacognitive component is an overarching component which directly influences the activation and directing of the knowledge acquisition and performance components. It is an awareness of the cognitive processes and can be further divided into two elements: metacognitive knowledge and metacognitive skills (Desoute, Rougers, & Buysse, 2001).

Metacognitive knowledge encompasses knowledge of our cognitive processes and strategies as well as of our cognitive ability. It involves knowing why, how, and when cognitive and performance strategies are most effective (Snyder et al., 2011). When it comes to the cognitive strategies, the gifted are more advanced in their strategy use even from a young age. They simply know more cognitive strategies which may also relate to the fact that they are better at creating a performance strategy for a novel problem (Carr, Alexander, & Schwanenflugel, 1996).

Metacognitive skills include the active regulation of our cognitive processes. It involves predicting the effort a task requires, planning on how to deal with a task, monitoring the process and evaluating whether you are getting to the desired end of the task (Desoute et al., 2001). These are all metacognitive strategies that are used to improve the problem-solving process (Gick, 1986). Enhanced metacognitive skills are related to better use of cognitive strategies, which are used to form a mental plan when solving a problem (Westwood, 2004). Gifted children adapt quicker after making a mistake and take more time to plan and execute strategies (Steiner, 2006). Siegler and Alibali (2005) state that all children possess the ability to plan from a very young age. However, Siegler and Alibali composed a list, based on several studies, of several reasons for children not to plan while solving a problem. Taking the time for planning an approach to solve the problem entails restraining oneself from acting immediately, an ability which is developed gradually during childhood. Planning also means spending time and effort on something that might not be successful. Gardner and Rogoff (1990) conducted a study in which they compared the amount of planning 4- to 10-year-olds did under two different conditions. In the first condition, children had to get from point A to point B while avoiding making wrong turns. In the second condition, the children received the same instructions along with the instructions that speed was important for this task. Only the 7- to 10-year-olds showed a difference in tactics when comparing the two conditions. The 7- to 10-year-old children in the first condition often took the time to plan the entire route in advance and thus reducing the number of wrong turns. In the second condition, the children planned a small portion of the route in advance and made the rest of the decisions along the way. Thus, children reduced the time spent planning when speed was perceived as an important element.

Knowledge acquisition

Strategies can be domain-specific (e.g., using the Pythagorean theorem in math) or general (Gick, 1986). If a problem has been faced before, and an effective domain-specific performance strategy is known, then the knowledge acquisition phase becomes unnecessary and one can continue straight to the performance phase. However, when confronted with a novel problem, general cognitive strategies are used in the knowledge acquisition phase. These strategies are intended to gain knowledge or information needed to solve the problem (Siegler & Alibali, 2005). Alessandro, Ignazi, and Perego (2000) constructed a list of five general problem-solving strategies: Free production, combining, analogy, visualization, and step-by-step.

Free production is the process of generating as many ideas as possible. This process is favoured as the strategy for new problems by some authors because the increase in the number of ideas also increases the likelihood of finding a good solution (Alessandro et al., 2000). It seems a more useful strategy when confronted with a problem that does not have a single solution, or perhaps as an introductory strategy to get acquainted with unfamiliar problem elements. Gifted children are accustomed to making discoveries on their own, which has been related to their internal drive to learn (Winner, 2000). In addition, research shows that gifted children are more productive in generating unusual ideas (Tan, 2013). It seems reasonable to argue that gifted children would be more inclined to use this strategy as well as be more effective in the performance of it. The *combining* strategy sees a problem as consisting out of smaller elements, combining these elements in different ways, can lead to the solution. Compared to the step-by-step strategy (discussed below), which is always used complying within the boundaries or rules of a problem, the combining strategy has no such restrictions. Thus when a former strategy does not lead to the solution, changing to a combining strategy can create a fresh look on the problem. This strategy is seen as essential in creative problem solving (Alessandro et al., 2000), which leads to the conclusion that creativity is important for the combining strategy. Gifted children's above average levels of creativity should allow them to perform this strategy better. *Analogy* is a solution finding process where problems with a known solution are compared to the current problem and any similarities would suggest that a similar strategy could be used for acquiring the solution. *Visualization* entails seeing the problem as a whole, while simultaneously understanding the different features and trying to look at it from different angles. *Step-by-step* is a strategy that involves seeing the problem-solving process as a path that can be broken down into smaller sub-goals. Means-end analysis is one such example whereby each step consecutively is chosen because it decreases the distance to the solution the most. Because gifted children easily know which steps to take when faced with a problem (Geake, 2009), it seems that they could execute this strategy with less effort. Different strategies can be chosen for different kinds of problems. Frederiksen (1984) categorises three kinds of problems: well-structured, semi-structured, and ill-structured problems. Well-structured problems have all the information needed to solve the problem with a certain algorithm, which is the case with all math problems in school. Ill-structured problems do not have a single correct answer and not one appropriate way to find the answer. According to Frederiksen, a semi-structured problem is similar to a well-structured problem in that it can have only one correct solution. But, unlike the well-structured problem, there are crucial steps missing in the problem-solving process that the children need to produce in order to solve the problem. In other words, there are multiple paths to the solution. These semi-structured problems require a step-by-step procedure to solve.

Important processes in the knowledge acquisition phase are: separating relevant from irrelevant information, integrating this information in a meaningful way, and relating it to formerly stored information (Siegler & Alibali, 2005). Gifted children seem to be more efficient in the knowledge acquisition process than non-gifted children which is directly related to superior encoding (Carr et al., 1996; Sternberg, 1999). This superior encoding allows them to quickly pick out and process the important information which leads to a better understanding of the problem (Johnson, Im-Bolter, & Pascual-Leone, 2003).

Performance

The last process is the actual performance of domain-specific strategies towards solving the problem. These performance strategies are the observable actions that derive from the strategies in the previous phases. For example, the metacognitive strategies may influence a change in actions due to unsatisfactory progress towards the solution. A step-by-step cognitive strategy may lead to actions where the focus lies on manipulating just one problem element at a time.

Gifted students are more efficient in selecting a strategy to use for a specific problem. Because of this efficiency, they show more consistency in their strategy use (Coyle, Gaultney, & Bjorklund, 1998). However, gifted children do not show superior problem-solving skills in all studies (Perleth & Wilde, 2009). One explanation for this result is that gifted children only perform better when a problem is challenging enough so that they must use their advanced metacognitive knowledge (Carr et al., 1996; Snyder et al., 2011).

Current study

The purpose of this research is to see whether a distinction between gifted and non-gifted can be found in problem solving, by looking at the children's use of performance strategies when solving a problem. Two groups, regular children and gifted children, were asked to solve a problem, that was novel to them. Both groups got the same problem and the same instructions. This allows the comparison and analysis of the strategies that both groups used. The task did not have a time limitation since this could affect the time they spent on planning.

The problem in this study was taken from the game 'laser maze' (Produced by Thinkfun, Inc.). Which was a board game with the goal to project a laser beam on a set target by placing objects with different kinds of mirrors in the right position.

Overall, the hypothesis was that gifted children would use more effective performance strategies. The effectiveness of the performance strategies was determined by the connection to cognitive strategies and their usefulness in the game. Both the visualization and analogy strategies are difficult to distinguish when looking solely at the actions performed by the children. However, the free production, step-by-step, and combining strategies can be connected to observations of the actions. First of all, we expected the gifted children to use a form of free production to get familiar with the mechanisms of the different objects before the start of the game. Then, because the game is a semi-structured problem, the expectation was to see children using performance strategies which can be linked back to a step-by-step cognitive strategy, while playing the game. Finally, because the combining strategy seems a useful alternative strategy and seems to fit the characteristics of the gifted children, we expected to see the gifted children using this strategy more often than the regular children.

In addition, we also tried to measure some characteristics of gifted students through their performance strategies. We expected to see gifted children spending more time planning. As well as having a quick understanding of the problem and the different elements and learning more from mistakes.

Method

Participants

The total sample consisted of N=49 children, of which 21 boys and 28 girls with an average age of 9.8 years (SD=0.4). All children were either 9 or 10 years of age. The research was conducted with both regular and gifted children. The regular group consisted of 12 boys and 13 girls with an average age of 9.9 years (SD= 0.4). The gifted group consisted of 7 boys and 15 girls with an average age of 9.6 years (SD=0.4). The regular children originated from two different elementary schools. From one school, the complete class participated. From the other school, the children were selected at random by their teacher. The gifted participants were selected from three different elementary schools, one of which was specifically for gifted children. From this school, 10 children participated. The requirements for this school were: a child had to have an IQ of 130 or higher, an ample amount of creativity, and motivation. The creativity and motivation levels were determined in conversations with the students and during a trial week in class. The other 12 children were diagnosed as gifted based on their test results and through a digital system for diagnosing gifted children (Sombroek, 2017). All participants were required to be fluent in Dutch and could not be physically limited in a way that prevented them from playing the game. Another requirement was that the children were not familiar with the game prior to the experiment. Two gifted children were excluded based on this last requirement. All parents were informed and gave active consent via their children's teacher.

Materials

The game 'laser maze' was used to observe the problem-solving strategies between gifted and non-gifted children. The game consisted of a game board, game-cards, a help-card, and several objects with different colours (see Figures 1, 3 and 4). The goal of this game was to project the laser beam to (a) specific target(s), by correctly placing and orienting the different objects.

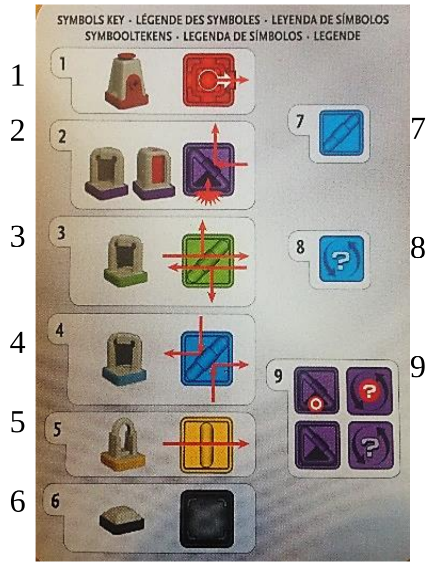

Figure 1. Help card: visualising the different objects of the game and how they interact with the laser beam.

Explaining the game

The help card, Figure 1, showed red arrows to visualize how the laser beam was influenced by different objects. The first object on the help card showed the red laser. The second object (purple) had two different sides. A mirrored side that caused a 90-degree bend in the laser beam and a red side which lit up when it was hit by the laser beam (as seen in Figure 2). Number nine showed four purple objects, two of which with a red marker. The red marker identified these objects as a target for the laser beam which meant that the beam had to land on the red side of that object. The third object is the green object. This object had two identical mirrors on either side which caused the laser beam to split into two. One beam reflected from this object at a 90-degree angle and the second beam went straight through the object. The blue, and fourth object only caused a 90-degree bend in the laser beam with identical mirrors on both sides. The yellow and black objects that could be seen on the help card (number five and six) were not needed in the games and were not given to the children. Number seven and eight on the help card showed how an object would look on the game card if it had a fixed direction or if it could be turned respectively. Figure 2 shows the laser beam lighting up the target. The laser beam could clearly be seen on the target but was difficult to see in the mirrors.

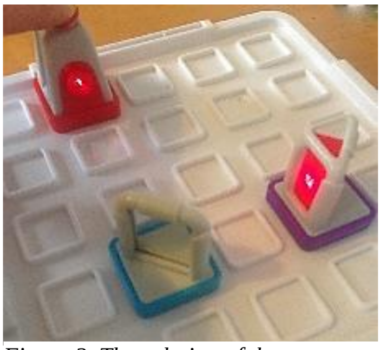

Figure 2. The solution of the introduction game.

The experiment

Two game-cards were used in the experiment, a simple introduction card and a more challenging game card. The second game card was selected to be challenging but not too difficult for both groups to solve. This card was chosen after four pilot tests with children around the same age as in this study. The objects given to the children were: one laser, one blue object, two green objects, and four purple objects. One green and one purple object were not needed for the solution but given to allow the children more freedom to play outside of the rules.

Figure 3a shows the game card used for the second game. The game card depicted the game board and all the objects needed for the game. The objects drawn on the board had a fixed position and should not be moved. The top-left corner, indicated by the green symbol, showed which object had to be included in the board game as well. The top-right corner of the game card showed the number of targets that needed to be reached with the laser beam. There were two targets on the game card. These targets were the two purple objects on the left, these were indicated by the red markers. All objects seen on this card had to be touched by the laser beam, except for the laser which produced the beam. The laser could be used as often and for as long as the children wanted. All objects had a fixed orientation, except for the ones indicated by a question mark. Only the green object should be moved. Figure 3b shows the solution for the second game card.

Figure 3a. The second game card.

Figure 3b. The solution of the second game.

Procedure

The participants were taken out of the classroom one-by-one and positioned in a different room in the school, where they were exposed to minimal distractions. First, the purpose and reason of the research were explained to them. In addition, they were told that they were going to play a game called laser maze and would be filmed while playing this game. They were asked to think out loud during the game and a brief explanation of this concept was given. The researcher asked what their birthday was and whether they knew the game. After this introduction, the camera was turned on and then the game was explained with all its objects. After this explanation, the introduction game started.

The goal of this game was to ensure that the children understood the rules and could practice thinking aloud. The researcher started the game by examining the game card and placing the laser on the board while thinking aloud. Then the game was handed over to the child. After the introduction game was solved and all questions about the rules of the game were answered, all the playing objects were taken from the playing board and the second game card was handed to the participant. Throughout both games, the children had the help-card next to them. Whenever a child did not think aloud, the researcher would ask questions such as: ‘What are you thinking now?’, or ‘Why are you doing that?’. During the second game, questions regarding the rules were answered to ensure that all children had a similar understanding of the rules. Other questions regarding the game, such as: ‘Did I put this in the right direction?’, were not answered and no help was given within the first 15 minutes. After 15 minutes hints were given to allow all children to finish the game and return to class within a reasonable time. The total session per child lasted between 10 to 35 minutes. The explanation and first game took between 4 to 8 minutes and the second game lasted between 2 to 30 minutes.

After the game, they were asked if they enjoyed the game and to reflect on how they tried to find the solution. Children found it difficult to remember what strategies they used or the reasoning behind their moves, therefore the information from this reflection was not used in the analysis. The thinking aloud data differed greatly in quality between children since some were not able to think aloud during the game. Because of this inconsistency, the analysis will not involve the thinking aloud aspect.

Qualitative Analysis

The analysis only involves the first fifteen minutes of the game, because help was given after 15 minutes. In total, 25 children finished within 15 minutes and their entire game was observed and analysed. The observation and analysis of the remaining 22 children ended at 15 minutes making 15 minutes their 'total time' in the analysis.

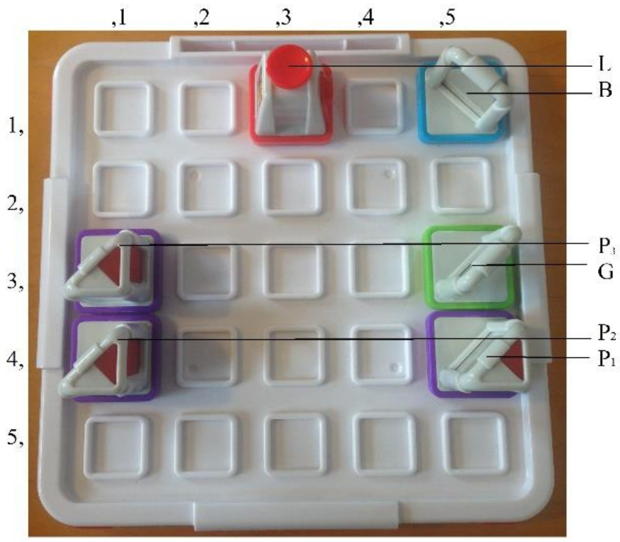

Figure 4. The board- and object codes.

Action log

In the first phase, the videos were watched and all actions were written down. In order to write down everything efficiently and fully, a code system was devised. All objects got a letter and, depending on whether more of the same objects were used, also a number. As can be seen in Figure 4, the laser was L, the blue mirror was B, the green mirror was G, the purple object on the right was P_1, the bottom-left purple object was P_2, and the top-left purple object was P_3. Also shown in the figure are the board place codes. For example, if the laser was correctly placed, the code "L1,3" was written. In addition, when the laser was turned correctly, the code was highlighted with green. If not, then the code was highlighted with orange and an arrow was drawn to indicate the direction to which the laser was pointed. If the object was not correctly positioned, the code was not highlighted. The direction of the other objects was visualised by drawing a backslash or forward slash. Because the purple objects had more than two ways to turn the object, a laser beam bouncing off the mirror was also drawn on the back- or forward slash (i.e. P_2 \ └). Each time an object was moved, the object code, board code, and direction were written down. If an object was turned but not moved then the object code with the number D (Draaien: Dutch for turning) and the direction was written down. If the action consisted only of pressing the laser then LP (Laser Press) was written down. If an action was performed after LP but the laser was still pressed while doing this next action than LnP (Laser nog Pressed: nog meaning “still” in Dutch) was written down in parentheses next to the code of the action. In some situations, a child took an object of the board and thereafter performed another unrelated action, which was indicated by the object code of the removed object in combination with a W (Weg: Dutch for “gone”).

All videos were viewed at least twice. In the second round, the observations relevant for the analysis were observed and written down more precisely. From these observations, eight variables were calculated and scored.

Action time

First, the total play time was calculated in seconds. Timing started when the children looked at the game-card and ended when they got all the pieces right and showed that they had found the answer, usually by saying something like ‘Yes’ or ‘I got it’. In situations where children did not find the answer in time (before they received the hints), their total time was set to 15 minutes. Next, the time participants spent on different actions was timed in seconds. Then the percentage of time in action from the total time was calculated. The criteria for timing of the actions were the following:

1) From the moment they picked up an object until the moment they put that object in a certain spot on the board, if:
    a) No other action happened in between picking that specific object up and putting it on the board.
    b) The movement towards a position on the board did not stop for three seconds or longer. Only picking it up and then continue holding that object was not timed as action.
2) Pressing the laser was considered an action which was timed only when the child seemed to be actively using the laser. For example, some kids pressed the laser almost continuously but did not interact with the laser beam for that entire time.
3) Taking an object of the board was considered an action if:
    a) In between picking it up and placing it back on the board, another object was moved.

   b) The object was placed on the table for more than three seconds after picking it up from the board.
4) When objects were kept in children's hands for more than three seconds, this action was not timed. However, when they continued and moved the object back on the board, the timing started.
5) The time it took from taking an object to putting it down was timed as an action, if:
   a) No other action was performed in between picking it up and placing it down.
6) Picking a piece of the board and then setting it back within three seconds was not counted as an action. Neither was turning an object back to the orientation it had before starting the turn.

The action time variable was used to measure the time spent on planning, which gifted children are inclined to do more according to literature. Based on the assumption that children perform fewer actions while planning, gifted children were expected to have a lower overall time spent in action.

Help card

The number of times a child consulted the help card was observed. Only the times when a child commented on using the card or made a distinct move towards the card (e.g., taking the card in their hands) was counted. The influence of the total time played was removed by converting this data into a percentage of the total time.

We expected less use of the help card in the gifted group. They process information quicker than regular students and generally have a higher understanding of the problem. Moreover, as the gifted were expected to learn more even before the start of the game due to a free production strategy, they will likely be better acquainted with the mechanisms of the objects. Therefore, they will probably need less aid from the help card.

Turned

The number of times an object was turned was counted. When an object was moved and turned simultaneously, this was not counted as a turn since it was already counted as a "move". In addition, turning an object turned 360 degrees was not scored, as it was not considered an action. These numbers were then calculated as a percentage of the total time.

Moved

The number of times an object was moved was observed and converted as a percentage of the total time. The moves were counted from the moment an object was placed on the board. Taking a piece of the board was not counted but then putting it back on was.

Research shows that gifted students are quick in understanding and learning from their mistakes which lead to the expectation of seeing a lower number on the *moved* and *turned* variable in the gifted group. Performing a higher number of moves and turns could also indicate a trial-and-error strategy which is a guessing strategy (Frederiksen, 1984). As explained, we expected more effective strategies from the gifted children which stands in contrast with guessing.

Free play

A distinction was made between children who played with the objects before the start of the games and those who did not. Some children started to play and learned from the playing objects without instruction from the minute they got them. Others immediately took the objects when they were given instructions about them and started to re-enact that which was explained. Both types of play were considered free play.

The free play variable was used to measure the free production strategy which the gifted children were expected to use more.

Alternative solution

The children were categorised in either finding or not finding an alternative solution. An alternative solution meant getting the laser-beam to two possible end-objects, without following (some of) the rules indicated on the game card.

The alternative solution variable was used to measure a combining strategy. We expected gifted children to find an alternative solution more often than the regular children. This meant having to perform actions not in line with the rules of the game to possibly gain a new insight into the problem.

Laser use

The laser could be used in two different ways, either with an action or without an action. Using the laser with an action meant pressing the laser while also performing another action with an object. The number of times a laser was pressed with and without an action was scored. Children were classified as “laser users without action” when the laser was pressed without performing another action for more than 80% of the total number of times the laser was used. When the number of laser presses, combined with another action, was between 20% - 50% of the total number of laser presses, these children were classified as “alternating laser users”. The children were classified as “laser users with action” when they combined pressing the laser with another action for more than 50% of the time.

When a child pressed the laser with an action, they held the laser pressed longer than, when it was pressed without action. Therefore, when pressing the laser with an action for more than 50% of all the laser presses, this tactic seemed to be chosen above the other tactic. Likewise, if the laser was pressed without action for more than 20%, this tactic seemed to be chosen. The ones that alternated did not seem to choose a specific strategy or chose to change it.

The laser use variable was used to measure a step-by-step strategy. The gifted children were expected to fall into the “laser users with action” category more often. This strategy gives more information about a single object, which could benefit children who reduced the overall goal, of solving the game, to a smaller goal of placing that object correctly.

Laser catch

The laser beam was only clearly visible on the targets. Thus, to reveal the path of the laser beam, children could use another object or their hands to put in between objects and catch the laser beam. The students were divided into two categories, one group did not try to catch the laser beam and the second group did do this at least once. As explained before, the laser beam was best seen when it hit the target and could be seen with difficulty in the mirrors. Some children needed a long time to discover how the laser beam moved from the laser to the target. This resulted in a lot of false assumptions about how the mirrors worked. Children who tried to catch the laser with an object or their body learned more quickly if their assumptions were correct or not.

The laser catch variable was also used to measure the step-by-step strategy. We expected to see more gifted students catching the laser, as this would lead to more information about a section of the game.

Quantitative analysis

To assess whether there was a difference between the gifted and regular group, the four categorical variables were analysed using the Likelihood Ratio Chi-square test due to the smaller sample size. The hypotheses of difference were accepted with a significance level of $p < .05$. The odds ratio was calculated for the effect size in the case of significance (Fields, 2009).

The four continuous variables were tested for normality for each group separately. The z-value was calculated using the skewness value. According to Hea-Young (2013), the hypothesis that the variable is normally distributed should be rejected when $Z > 1.96$. Apart from the regular group for the help card variable (Z = 3.1293), all measures were normally distributed.

The independent t-test was used to test for significance between the two groups on the variables that were normally distributed. For the help card variable, the non-parametric Mann-Whitney U-test was used to test the significance of the difference. For both these tests, a significance level of $p > .05$ means that the hypothesis is rejected.

In addition, we used a latent class analysis (LCA) to test if different patterns in strategy use could be found between the groups. An LCA determines whether there is a latent (unobserved) variable that explains a difference in patterns within the manifest (observed) variables. Both the latent and manifest variables are categorical with this type of analysis. LCA fits the respondents into a number of different groups called latent classes based on the patterns within the observed variables. This analysis can be used when a qualitative difference between people is assumed (Straatemeier & Van der Maas, 2008). In this case, a difference between the gifted and regular group is presumed. Because the game used in this research has never been used in an experiment such as this, the LCA was first used to confirm that such a difference in patterns of strategies could be found using this method. Then the analysis will continue to investigate whether this differentiating feature is giftedness.

The variables used in this analysis were chosen based on their graphical representation between the groups and if potential differences could be seen between the groups. This led to four variables: turned, moved, laser use, and free play. For that reason, the turned and moved variables had to be converted into categories. The percentages of these variables were all within the 10%. Four categories of each 2.5% were created: scarcely, sometimes, often, and very often.

This study has a relatively small sample size, for this reason the best fitting model was determined by looking at the Bayesian information criterion (BIC) (Schwarz, 1978). The model with the lowest BIC score is the model that best fits the data (Wagenmakers & Farrell, 2004). Thereafter, the model with the best fit was tested with covariates to examine which measure might be related to the latent variable separating the classes.

Results

Table 1 shows how the gifted and regular group scored, in percentages, on the four categorical variables. To test the hypothesis of difference on these variables between the gifted and regular group, the Likelihood Ratio Chi-square test was used. The tests showed no significant difference between the gifted and regular students for the alternative solution ($\chi^2(1) = .35$, $p = .553$), the laser use ($\chi^2(2) = 4.91$, $p = .086$), and the laser catch ($\chi^2(1) = .08$, $p = .775$)

variables. There was a significant difference between the gifted and regular group on the free play variable, χ^2 (1) = 7.44, p = .006. Based on the odds ratio, gifted children were 7.96 times more likely to play before the start of the game than the regular children. An additional t-test also showed that those children that used the free play strategy finished the game significantly earlier than those that did not, t (45) = 2.99, p = 0.005.

Table 1 Percentage of Respondents on Categorical Variables

Variable	Group	Categories		
Free play		No	Yes	
	Regular	92.0	8.0	
	Gifted	59.1	40.9	
	All	76.6	23.4	
Alternative solution		No	Yes	
	Regular	88.0	12.0	
	Gifted	81.8	18.2	
	All	85.1	14.9	
Laser use		Without action	Alternating	With action
	Regular	76.0	16.0	8.0
	Gifted	50.0	18.2	31.8
	All	63.8	17.0	19.1
Laser catch		No	Yes	
	Regular	72.0	28.0	
	Gifted	68.2	31.8	
	All	70.2	29.8	

Table 2 shows the means per group for the four continuous variables. The independent t-test and a Mann Whitney-U test was used to test for difference between groups on these variables. The tests revealed no significance for the three variables: action time (t (45) = .03, p = .979), turned (t (45) = -.42, p = .680), and moved (t (45) = -.66, p = .516). The usage of the help card in the regular group (*Mdn* = 0.44) also did not differ significantly from the gifted group (*Mdn* = 0.44), *U* = 263.50, *z* = -.25, p = .806.

Table 2. Mean Scores and Standard Deviations of Continuous Variables in Percentages

Variable	Group	M (in %)	(SD)
Action time	Regular	38.31	(13.00)
	Gifted	38.21	(13.28)
Help card	Regular	0.56	(0.60)
	Gifted	0.54	(0.47)
Turned	Regular	4.54	(2.35)
	Gifted	4.83	(2.41)
Moved	Regular	4.06	(2.09)
	Gifted	4.48	(2.27)

Table 3. Percentage of Respondents for the Variables Converted into Categories for the LCA

Variable	Group	Categories			
Turned		Scarcely	Sometimes	Often	Very often
	Regular	28.0	32.0	28.0	12.0
	Gifted	22.7	22.7	45.5	9.1
	All	25.5	27.7	36.2	10.6
Moved		Scarcely	Sometimes	Often	Very often
	Regular	24.0	48.0	24.0	4.0
	Gifted	22.7	27.3	40.9	9.1
	All	23.4	38.3	31.9	6.4

Table 3 displays the percentages of respondents per category for the turned and moved variables that were converted to categories in order to be used in the LCA along with the laser use and free play variables. The LCA was used to test for an overall difference in the pattern of strategy use. Table 4 shows that the model with the lowest BIC score, thus the best-fitted model, is with two classes.

The LCA with two classes was repeated with the gifted variable as a covariate which resulted in a higher BIC score and results showed that this variable had a non-significant relation to the data (χ^2 (1) = .81, p = .369).

Table 4. Fit Measures of Latent Class Models

Number of classes	BIC
1	411.2565
2	410.2567
3	440.4839
4	472.9916

Note. BIC= Bayesian Information Criterion

Table 5 shows the probabilities of the respondents belonging to a certain category per class. For example, the chance that someone belonging to the first class scored “scarcely” on the turned variable, is 57.82%. Class one scores low on the turned and moved variables and highlights a clear preference for using the laser without action. The second class, in turn, demonstrates a more active profile except for the last variable, free play. Both classes score higher in this variable on the ‘No’ category, with the second class displaying only a slightly less strong preference. Activity level being closely related to the latent class membership is further indicated by a significant result for action time as a covariate (χ^2 (1) = 20.04, $p < 0.001$). No other covariate tested had a significant outcome. Class one (M = 29.61, SD = 13.55) scored significantly lower on the action time variable than class two (M = 45.25, SD = 7.06). These results show a behaviourally active and a behaviourally passive class.

Table 5. Conditional Item Response Probabilities Per Class in Percentages

Variables	Categories	Class 1(N=21)	Class 2(N=26)
Turned	Scarcely	**57.82**	.00
	Sometimes	**34.21**	22.48
	Often	7.97	**58.47**
	Very often	.00	**19.05**
Moved	Scarcely	**53.01**	.00
	Sometimes	**44.99**	31.42
	Often	.00	**57.15**
	Very often	.00	**11.43**
Laser press	Without action	**93.08**	40.71
	Alternating	6.92	**25.00**
	With action	.00	**34.29**
Free play	No	**79.23**	74.52
	Yes	20.77	**25.48**

Discussion

Literature suggests a qualitative difference in the way of thinking and acting, between gifted and non-gifted children, in the domain of problem solving. The aim of this study was to examine the difference in performance strategies used by gifted and regular children while solving a problem. The game ‘laser maze’ was used and eight performance strategies were observed and analysed. Three cognitive strategies as described by Alessandro et al. (2000): free production, step-by-step, and combining, were expected to be seen in performance strategies of the gifted group. Other performance strategies were observed to measure characteristics of gifted students in problem solving as described in the literature. In addition, an overall difference in the pattern of strategy use between the two groups was analysed.

The results confirmed the hypothesis that gifted children were more likely to interact with the game objects before the start of the game than the regular children. None of the other strategies were found to distinguish between the two groups. In addition, two different patterns in strategy use were found. The difference was related to the time children spent performing actions. As the game was never used in a similar study, the two-class outcome confirmed the postulation that the game could distinguish between different students based on the strategies used while playing.

Free production

The results showed that the gifted children were almost eight times more likely to play with the game objects of their own accord before the start of the game when compared to regular children. Free production is a cognitive strategy described by Alessandro et al. (2000) with the purpose of finding a lot of ideas. We argued that this strategy would not be effective during the game, but which might be helpful before the start of the game. The use of this strategy before the game would allow the children to get better acquainted with the mechanisms of each object, which could lead to solving the game faster. We expected gifted children to show more of this playing behaviour before the game, based on them being used to making discoveries on their own (Winner, 2000), and being more productive in generating unusual ideas as well (Tan, 2013). The results confirmed our hypothesis, thus making the connection between a free production strategy and free play behaviour. Furthermore, the results showed that the free play strategy was a more effective strategy because the children who used this strategy found the solution to the game significantly earlier than those that did not. However, the time taken to play before the game was not included in the total game time.

Teaching this strategy to children in school might be beneficial for similar problem types. However, more research is needed to confirm this connection. Preferably a study in which there are several observers who are unaware of which children are gifted. This was not the case in our study, as there was only one observer who knew in which group a child belonged, this might have led to a bias.

Step-by-step

Results showed no differences between the gifted and regular group on both the laser use and laser catch variables. These performance strategies were measured to observe the use of the cognitive step-by-step strategy. The step-by-step strategy was presumed to be the most effective for the type of problem used in our study (Frederiksen, 1984). We expected to see this strategy more often in the gifted group because research states that gifted children choose more effective strategies (Coyle et al., 1998) and easily know which steps to take when confronted with a problem (Geake, 2009).

It was expected that gifted children would press the laser more often whilst performing an action than the regular children because it gives more feedback on a single action. However, the literature also shows that gifted children process information quicker (Carr et al., 1996; Sternberg, 1999). This could be related to the absence of significant results. Perhaps they quickly learned what the effects of their actions were on the laser beam and did not need to keep pressing the laser with actions to learn more. The regular children would not have this advantage, therefore should have been using a strategy that would gain them more information. However, if the regular children are not more inclined to choose the most effective strategy, then it would lead them to choose a similar strategy as the gifted group. This could explain the absence of difference between the groups.

Children who tried to catch the laser with an object or their body learned more about each element separately. This was the reason to include the laser catch variable to observe a step-by-step strategy. Only 30 percent of all children displayed the laser catch behaviour. In a relatively small sample, this percentage might be too low to be able to detect a smaller effect size between groups. Perhaps if the study was repeated with a larger sample size more differences could be detected between the groups. Another explanation for the lack of difference on this variable could be related to the significant result on the free play variable. The children who displayed the free play behaviour started the game with more knowledge about the mechanisms of the objects. Perhaps because more gifted children had this knowledge advantage, they would gain less from a laser catch strategy compared to the regular children.

Combining

There was no significant difference in the number of alternative solutions between the groups. This performance strategy was used to measure the use of the cognitive combining strategy. This strategy was proposed to be an effective strategy to get a new perspective on the problem and its elements. Creativity is required for this strategy so based on the facts that gifted children are both creative (Miller, 2012) and select more effective strategies (Coyle et al., 1998) we expected to see more alternative solutions within the gifted group. Perhaps the structured nature of the problem did not cause enough stimulation for the gifted students to use their creative ability and find alternative solutions. Treffinger, Selby, and Isaksen (2008) proposed a distinction between structured and ill-structured problems. They stated that the former relies more upon knowledge and memory while the latter requires creativity and inventiveness. There have been conflicting results in studies of giftedness and problem solving. One of the explanations might be that a problem was used which was not challenging enough to stimulate the gifted students in using their full capacities (Carr et al., 1996; Snyder et al., 2011). Perhaps both difficulty and the level of structure in a problem could be related to challenging a gifted individual to use their unique qualities or not. Another interesting outcome related to this argument is the fact that the only variable with a significant difference between groups, is free play. This was also the only variable observed outside the structure of the game. This seems to substantiate the statement that the structured nature of the game affects the behaviour of the gifted students. When the gifted children are not challenged to use their unique capabilities, then it seems likely they would not differ from the regular children.

Action time

The results showed that neither the gifted nor the regular group had a distinct preference for either spending more time on performing actions or spending more time on thinking. Previous research showed that gifted children spent more time on planning while trying to solve a problem (Steiner, 2006). Thus, the expectation was to observe gifted children spending less time in action. Perhaps the operationalization of planning as time spent without action is incomplete. The approach has been as that of a unidimensional concept while it might be interesting to see if looking at it from a multidimensional angle would influence the results. The children who scored low on the action time variable did seem to spend more time on planning because when asked what they were thinking of, the most common answer was some variation of ‘I am thinking about what I should do’. Nevertheless, the children who were busy making moves and turns could also have been planning. Davies (2003) proposes a similar distinction which he calls initial planning and concurrent planning. He suggested that when no external constraints are forcing a certain type of planning, there are three other factors influencing the type that will be chosen. These factors are: individual preferences, the complexity of a problem, and at what stage in the problem-solving process a person is. In this study, all children had the same complex problem to solve and the time spent on planning was measured over the entire game time, thus leaving individual preferences as a likely reason for explaining the differences. This difference does not seem to be related to giftedness. Research shows that planning before action can increase with an increased cost of viewing the goal-state (Waldron, Patrick, & Duggan, 2011). Therefore, it would be interesting if the same study was conducted with an increased cost of looking at the game card (e.g., restricting the number of times children can look at the game card). Overall, it seems that there is a need for more research in planning while solving different types of problems under various conditions.

Help card

The results did not confirm the hypothesis that the gifted children would use the help card less than regular children would do. This hypothesis was based on literature which showed that gifted children process information faster (Carr et al., 1996; Sternberg, 1999)**.** Observing this behaviour was difficult because the help card was often next to the game board and most of the times, the eyes were not visible on camera which would lead to some uncertainty in the measure. In future research, an eye-tracking system would be useful in limiting this bias.

One explanation for the absence of significance could be that using the game card was another facet of the type of planning the gifted children used. These conflicting factors may nullify both effects on this measure.

Turned and moved

The results showed that neither group scored considerably higher or lower than the other group in the number of moves or turns they made. A lower score was expected on both variables for the gifted children. Because gifted children learn more from their mistakes (Steiner, 2006), it was presumed to result in being quicker in finding which turn or move was more likely to get them closer to the solution. Furthermore, a higher count of moves and turns was related to more trial-and-error which was not the most effective strategy, and research suggests that gifted children choose more effective strategies. Considering the two different types of planning, it might not be as easy as looking at a moved or turned variable separate from the other variables and labelling one type more effective than the other. That is why a latent class analysis was also performed.

Latent class analysis

After a statistical analysis on the separate variables between gifted and regular children was performed, a latent class analysis (LCA) was performed to see whether there might be a difference in the pattern of strategies used. The LCA divides the participants into classes based on a pattern in their data which is caused by a latent (unobserved) variable. The hypothesis was that two classes would emerge with giftedness as the latent variable. The four variables (turned, moved, laser use, and free play) that showed the most differences within the groups based on their graphs, were used in the LCA. The results showed that a two-class model was the best-fitted model, but the latent variable was not related to giftedness. However, it was significantly related to the percentage of time spent in action. The scores on the variables for each class suggested that a distinction between a behaviourally active and a behaviourally passive problem solver could be observed. This is in line with the two types of planning, during and before action, that were discerned above. A problem-solving type or style can be described as "a relatively stable preference an individual expresses when approaching problems, considering information, and making decisions" (Houtz & Selby, 2009, p. 18).The active type was defined by higher scores on both the moved, turned, and laser use category whereas the passive type showed lower scores in those categories. The free play variable was not a distinguishing factor as both groups showed a higher probability of not showing this behaviour.

Metallidou and Platsidou (2008) reviewed the psychometric properties of Kolb's Learning Style Inventory (LSI-1985). Kolb (1984) suggested that students can differ in their type of learning along two bipolar dimensions: abstract conceptualization(AC) vs. concrete experience(CE) and active experimentation(AE) vs. reflective observation(RO). Some studies observed similar dimensions as put forth by Kolb, however, there are several other studies that found AC/AE and CE/RO dimensions (Metallidou & Platsidou, 2008). Both dimensions have on one side a more thoughtful, inactive approach (AC and RO), and on the other side an active discovery approach (CE and AE). This is in line with the two types found with the LCA.

Both classes found in this study seemed to have their own pitfalls. The extremely passive students seemed to take more time thinking about actions. When asked what they were thinking, some of these students made statements about knowing what did not work (without trying) and thinking about what did work. Why they did not try to test if they were right in thinking that something did not work might be related to wanting to avoid making mistakes. In turn, this might be related to why they performed fewer actions. The preference of thinking over action seemed to result in a prolonged game time, as well as a longer persistence of false assumptions about certain mechanisms of the game objects. The overactive students, however, could be too busy with making moves and turns that they miss what the effect of that action is and learn from it. The possible benefit of taking a more thoughtful approach was gaining a better understanding of the game and its solution. Whereas the active approach sometimes led to finding the answer by chance which does not require an understanding of why that is the solution. The benefit of the active approach was more visual feedback, which might lead to disproving of false assumptions faster if all of the feedback is actually processed. Further research into the active and passive student, and their strengths and weaknesses, is advisable because studies have shown the importance of instructions adapted to the individual style of thinking (Gagne & Wager, 2002; Sternberg & Grigorenko, 2002).

In this study, no separate class for the gifted was found and there does not seem to be one single class to fit all gifted children. The results showed that the passive and active types are also represented in the gifted group. Due to a limited sample size, the LCA was restricted in the number of classes to test for. Further research with a larger sample size is needed to test this hypothesis. If there are different types of problem solvers within the gifted population this could also be related to the reason for finding very little significance in the first analyses. The two types, active and passive, might cancel out each other's effect when looking only at the means of the whole group. Gifted and regular children can still differ in problem solving but a more complicated model may be needed to encompass these differences.

All measures observed during the process of solving the problem used in this study were unable to differentiate between gifted and regular children. Previous literature assigned the level of difficulty of a problem as the cause of absent significant result in similar research (Carr et al., 1996; Snyder et al., 2011). In this study, we used a problem that proved to be a challenge for both the gifted and regular group. Therefore, the difficulty of the game does not seem a likely cause for not finding significant differences between the gifted and regular children. Neber and Neuhaus (2013) proclaim that the problem given to students, is the single-most influencing factor in the student's problem-solving process. The problem used in this research was a semi-structured, single solution game. Further research is needed to analyse the influence of this type of problem on the student's problem-solving process.

Conclusion

Based on this study we cannot make a clear distinction between gifted and regular children concerning their observable problem-solving strategies. Further research should focus on the effect of the type of problem on the problem-solving strategies and the differences in the type of planning between the gifted and regular children. The type of problem used in this study might be restricting for the gifted children to allow their own type of thinking. We can conclude that gifted children are more inclined to play and discover with the problem objects before having to solve the actual problem. This behaviour was an efficient strategy thus encouraging it in other children could be beneficial for this type of problem. Another conclusion we can draw from this study is that there seems to be a distinction between a behaviourally active and behaviourally passive problem solver. Further research into this topic is required to confirm these findings. The more we learn about the individual differences in problem solving, the better we can adapt the educational system to individual needs. In addition, finding observable differences between gifted and regular children could help the teachers notice gifted children earlier and ultimately providing education better suited to their needs. Learning more about the strengths of gifted children could also benefit regular children. Teaching the regular students efficient strategies used by gifted children, such as the free production strategy, could improve the performance of the regular students.

References

Alessandro, A., Ignazi, S., & Perego, P. (2000). Metacognitive knowledge about problem-solving methods. *British Journal of Educational Psychology*, 1-16.

Carr, M., Alexander, J. M., & Schwanenflugel, P. J. (1996). Where gifted childeren do and do not excel on metacognitive tasks. *Roeper Review*, 212-217.

Coyle, T. R., Gaultney, J. F., & Bjorklund, D. F. (1998). Giftedness and variability in strategic processing on a multitrial memory task: Evidence for stability in gifted cognition. *Learning and Individual Differences*, 273-290.

Dai, D. Y. (2009). Essential tensions surrounding the concept of giftedness. In L. V. Shavinina, *International handbook on giftedness* (pp. 39-80). Quebec, Canada: Springer Science.

Davidson, J. E. (2009). Contemporary models of giftedness. In L. V. Shavinina, *International handbook on giftedness* (pp. 81-97). Quebec, Canada: Springer Science.

Davies, S. P. (2003). Initial and concurrent planning in solutions to well-structured problems. *The Quarterly Journal of Experimental Psychology*, 1147-1164.

Desoute, A., Rougers, H., & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities*, 435-447.

Duncker, K. (1945). On problem solving. *Psychological Monographs*, i-113.

Fields, A. (2009). *Discovering statistics using SPSS.* Thousand Oaks: Sage Publications Ink.

Frederiksen, N. (1984). Implications of cognitive theory for instruction in problem solving. *Review of Educational Research*, 363-407.

Gagne, R., & Wager, W. (2002). *Principles of instructional design.* Belmont: Wadsworth.

Gallagher, J. J. (2015). Education of gifted students: A civil rights issue? *Journal for the Education of the Gifted*, 64-69.

Gardner, W., & Rogoff, B. (1990). Children's deliberateness of planning according to task circumstances. *Develomental Psychology*, 480-487.

Geake, J. G. (2009). Neuropsychological characteristics of academic and creative giftedness. In L. V. Shavinina, *International handbook on giftedness* (pp. 261-274). Quebec, Canada: Springer Science.

Gick, M. L. (1986). Problem-solving strategies. *Educational Psychologist*, 99-120.

Guldemond, H., Bosker, R., Kuyper, H., & Van der Werf, G. (2007). Do highly gifted students really have problems? *Educational Research and Evaluation*, 555-568.

Hea-Young, K. (2013). Statistical notes for clinical researchers: assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, 52-54.

Houtz, J. C., & Selby, E. C. (2009). Problem solving style, creative thinking, and problem solving confidence. *Educational Research Quarterly*, 18-30.

Hui, A. N., Wu-Jing He, M., & Suk Ching Liu, E. (2013). Creativity and early talent development in the arts in young and schoolchildren. In A. Tan, *Creativity, talent and excellence* (pp. 75-87). Singapore: Springer.

Johnson, J., Im-Bolter, N., & Pascual-Leone, J. (2003). The development of mental attention in gifted and mainstream children: The role of mental capacity, inhibition, and speed of processing. *Child Development*, 1594-1614.

Kolb, D. A. (1984). *Experimental learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice Hall Inc.

Metallidou, P., & Platsidou, M. (2008). Kolb's Learning Style Inventory-1985: Validity issues and relations with metacognitive knowledge about problem-solving strategies. *Learning and Individual Differences*, 114-119.

Miller, A. L. (2012). Conceptualizations of creativity: Comparing theories and models of giftedness. *Roeper Review*, 94-103.

Never, H., & Neuhaus, B. J. (2013). Creative and problem-based learning (PBL): A neglected relation. In A.-G. Tan, *Creativity, talent and excellence* (pp. 43-56). Singapore: Springer.

Perleth, C., & Wilde, A. (2009). Developmental trajectories of giftedness in children. In L. V. Shavinina, *International handbook on giftedness* (pp. 319-335). Quebec, Canada: Springer Science.

Renzulli, J. S. (2000). The identification and development of giftedness as a paradigm for school reform. *Journal of Science Education and Technology*, 95-114.

Robertson, S. I. (2005). *Problem solving.* East Sussex: Psychology Press.

Saunders Wickes, K. N., & Ward, T. B. (2009). Creative cognition in gifted youth. In L. V. Shavinina, *International handbook on giftedness* (pp. 381-396). Quebec, Canada: Springer Science.

Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*, 461-464.

Siegler, R. S., & Alibali, M. W. (2005). *Children's thinking.* Upper Saddle River, New Jersey: Pearson Education International.

Snyder, K. E., Nietfeld, J. L., & Linnenbrink-Garcia, L. (2011). Giftedness and metacognition: A short-term longitudinal investigation of metacognitive monitoring in the classroom. *Gifted Child Quarterly*, 181-193.

Sombroek, M. (2017, 06 20). *Wat is DHH?* Retrieved from DHH-PO: http://www.dhh-po.nl/over-dhh/wat-is-het/

Steiner, H. H. (2006). A microgenetic analysis of strategic variability in gifted and average-ability children. *Gifted Child Quarterly*, 62-74.

Sternberg, R. J. (1999). The theory of successful intelligence. *Review of General Psychology*, 292-316.

Sternberg, R. J. (2004). *Definitions and Conceptions of Giftedness.* Thousand Oaks: Corwin Press.

Sternberg, R. J., & Grigorenko, E. L. (2002). The theory of successful intelligence as a bisis for gifted education. *Gifted Child Quarterly*, 265-277.

Stoeger, H. (2009). The history of gifted research. In L. V. Shavinina, *International handbook on giftedness* (pp. 17-38). Quebec, Canada: Springer Science.

Straatemeier, M., & Van der Maas, H. L. (2008). Children’s knowledge of the earth: A new methodological and statistical approach. *Journal of Experimental Child Psychology*, 276-296.

Tan, A.-G. (2013). *Creativity, talent and excellence.* Singapore: Springer.

Treffinger, D. J., Selby, E. C., & Isaksen, S. G. (2008). Understanding individual problem-solving style: A key to learning and applying creative problem solving. *Learning and Individual Differences*, 390-401.

Van Tassel-Baska, J., & Stambaugh, T. (2005). Challenges and possibilities for serving gifted learners in the regular classroom. *Theory into Practice*, 211-217.

Wagenmakers, E.-J., & Farrell, S. (2004). AIC model selection using Akaike weights. *Psychonomic Bulletin & Review*, 192-196.

Waldron, S. M., Patrick, J., & Duggan, G. B. (2011). The influence of goal-state access cost on planning during problem solving . *The Quarterly Journal of Experimental Psychology*, 485-503.

Westwood, P. (2004). *Learning and learning difficulties: A handbook for teachers.* Camberwell, Victoria: ACER Press.

Winner, E. (2000). Giftedness: Current theory and research. *Current Directions in Psychological Science*, 153-156.