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Attention and Action during the Design and Technology Lesson: by fine-tuning task characteristics

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In this paper, pupils' design behaviour is regarded as an expression of active knowledge acquisition. Four cases of building a task structure, which supports effective discovery learning, were investigated. We focus on simple characteristics in a model to explain the effects of the structure on task execution. It reconciles the advantages of direct instruction and constructionism. The model offers an easy way to immediately denote pupils' behaviour during the lesson. The idea is that the model can function as a heuristic and becomes manageable for use by the teacher during the lesson. In this way it strongly serves formative evaluation. In the first case we observed the following characteristics of the task underpinning attentive and active design behaviour:

- Success criteria formulated during task instruction, guided performance and evaluation
- The task was both challenging and doable
- A joint evaluation of performance results and methods that concluded the task led to shared knowledge and language

In the second case, we researched the effect of enhancing skilfulness of focused observation on the quality of discovery and subsequent invention. In the third case, we observed that a familiar situation benefitted the start of the performance. However, the absence of a joint evaluation led to limited shared knowledge and shared language regarding the task. This hindered pupil's rise of clear expectations about the expected results. In the last case, we researched the effect of enhancing skilfulness of analysis on the quality of verbal expression of discovery and subsequent invention. The thinking hats of De Bono were used as instruments to express ideas about a cuddly toy. The four cases together resulted in a simple model based on task characteristics that furthers active discovery and invention.

Key Words: D&T task, pupil autonomy, class language, joint evaluation, Montessori principles.

1. INTRODUCTION AND LITERATURE

Figure 1. Attentive behaviour during the D&T lesson

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A generally heard difficulty during Design & Technology education is the accomplishment of prolonged attentive and active behaviour of the pupils. The consequence of this is a failed lesson, because attentive and active behaviour is necessary for getting fresh ideas and motivation to reconstruct former ideas. This difficulty might be the result of ineffective use of either "direct instruction" or "constructionism".

Direct instruction benefits clearness for pupils about the aim of a lesson, but can hinder pupil's natural learning process (Gopnik, 2012).

Constructionism benefits the interaction of the hand and the mind (Papert & Harel, 1991), but can lack guidance towards learning goals (Kirschner, Sweller, Clark, 2006).

Natural learning is benefitted by using direct instruction in a coaching way. By using a collection of design tasks, control can be exercised subtle through restrictions built into these design tasks (Kimbell, 1994). Also Sennett (2009) makes clear that one job can be seen as a collection of many tasks, by emphasizing the significance of details; e.g. the grip on the pencil, the pressure on the chisel. To accomplish this, one lesson can be transformed into multiple events. One event can be used to introduce the point of the lesson, to control insight and activate former knowledge. Then, the other events can be used to instruct pupils on specific challenges, accompanied by clear expectations about outcomes. Joint evaluation of an event to create joint insights accompanied by joint language can function as a base for a next event (Lemke, 2000; Mercer, 2013; Black & Wiliam, 2009).

Guidance during constructionism can be found in borders combined with facilitation. Teachers in the Montessori tradition (Montessori, 1912) continuously work on familiar borders, where within pupils can autonomously discover and practice resulting in simultaneous designing and knowledge acquisition. The importance of knowledge gained by experience as an anchor for abstract thinking is recently confirmed by Hayes & Kraemer (2017). Sennett (2009) arguments that doing a job properly takes the time it takes. While we are working, submerged processes of thought and feeling are in progress.

A bordered task also protects pupils against overwhelm, that stops them to learn (Dewey, 1910). Keeping the task small and manageable, accompanied by clear expectations about the outcomes, is a way to border a task. This is in accordance with the ideas of Vygotsky (1978), who argues that the function of an educational task is to create a bounded "cognitive conflict" in the pupils. An unbounded cognitive conflict can result in passiveness or frustration, whereas a bounded cognitive conflict initiates reconsideration of ideas. Thus, the clarity of a task is of importance.

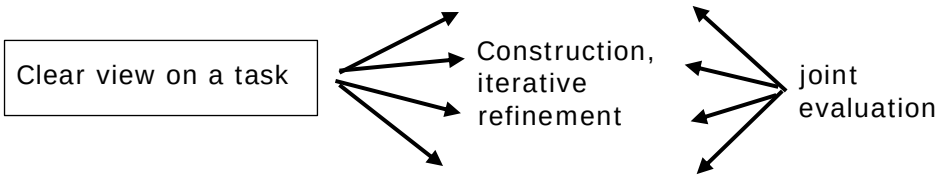

Figure 2. Construction and iterative refinement are furthered by a clear view on a task and joint evaluation.

2. METHODOLOGY

In this paper, we focus on that characteristics of tasks leading to a clear view on tasks. The results of our case-studies are described and combined to provide an overview of task elements activating pupils and leading to discovery and invention.

The central research question is: "*What are beneficial characteristics of the structure of a task allowing pupils to learn through discovery?"*

We explored four cases. Important questions were: "What do pupils need to start discovery?", "What do pupils need to start invention?"

An important feature of all cases was the exploration of unusual educational situations by questions such as "What will happen if the pupils have to collaborate with a non-chosen partner?" or "What will happen if the teacher doesn't intervene at all during the lesson?" or "What will happen when the teacher asks the pupils (4-6 year olds) to look at an object for a long time?" or "What will happen with the verbal expression of 4-6 year olds, when the teacher offers an instrument for deconstructing complexity"?

All cases encompassed three periods, which allowed the separate exploration of different conditions. A side effect of the use of three periods during all four case studies was that pupils' knowledge and skills increased along the way (Pirttimaa, Husu & Metsärinne, 2017). Each case is reported below, describing the task and accompanying discovery behaviour.

2.1. Case study 1: The marble-boat

2.1.1. The task

Five Montessori principles were selected to shape this design assignment: freedom of choice, self-checking, iteration, collaboration and presentation. The pupils (6-8 year olds) were given the task: ''Fold a piece of aluminium foil so it can hold the weight of marbles when it lies on the water. The more marbles it can hold, the better.'' By counting the number of marbles, the pupils could check the result themselves.

The same assignment was given three times with minor variations. The first time, the pupils had to work in self chosen pairs. The second time, the pupils had to work in non-chosen pairs, the third time they had free choice in working alone or in self chosen pairs and in carrying out the task or not. They could use their initiative to present their boat for a video-camera. A joint presentation of intermediate boats together with reflection at the end of each period was added to the Montessori conditions with the objective to set the task for the next period. See Looijenga, Klapwijk, de Vries (2015) for a complete description of the case-study.

2.1.2. Discovery behaviour of the pupils

The task was clear to all students quickly. The situation did not require unmastered skills and made all pupils start the performance easily. The iterated task gave the following results: the pupils showed an increasing sense of control and an increasing detailed insight in what to do for maximum results during the three work periods. Because of their focus on the explicit criterium for success (Clarke, 2001); "make a boat that can hold as many marbles as possible without sinking.", they gained insight into the causal link between the size of the surface that has to hold the marbles, and the number of marbles held. The pupils refined their insights by looking at each other and talking together. It stimulated continued building and testing. The joint presentation of and reflection on the intermediate boats led to reasoning. Working together with a non-chosen partner in the second work period did not stimulate active and enthusiastic behaviour, albeit joint evaluation showed increased insight. Most pupils were motivated to go on iterating until they reached conscious insight. A few pupils continued building and testing new marble carriers until they reached very high, near maximum results.

Figure 3. Boat holding 360 marbles

2.1.3. Conclusions

The simple, challenging task and the familiar situation, together with the clear expectations not only furthered discovery and invention skills in the pupils, but also collaboration and interaction during the performance of the task. In addition, the task structure served the joint presentation of and the reflection on the (intermediate) boats.

The teacher had ample opportunity to observe.

Additional literature about capacity (Dewey, 1910) capability, development and metacognition (Zohar & Dori, 2012, pp. 1-19), confirmed the relationship between the way the task was structured and the observed results.

In short; the beneficial task characteristics were:

- giving a simple and challenging task,
- focusing on a familiar situation,
- including simple and clear criteria for successful performance.

2.1.4. Next question

The results showed that collaboration and interaction during the performance of a task are important. But are they sufficient to enable aimed discovery and invention?

2.2. Case study 2: How to be an explorer of the world

2.2.1. The task

The explorations in the book of Keri Smith were chosen to practice observation. Keri's unusual well defined criteria for successful observations easily lead to fresh views, resulting in discovery (Keri Smith, 2008), also with very young pupils (4-6 year olds).

In three periods, the pupils experienced three different explorations.

The first exploration was about discovering unseen things in familiar surroundings (the classroom). A whole week long, this exercise was practical applied in discovering things to tidy up.

The next exploration was about being/becoming a real artist. A real artist is very skilled in ordinary things, like washing up, setting the table for dinner, comforting your little brother, helping other pupils and so on. The whole week, the pupils tried to become real artists in as many activities as possible.

The last exploration was about observing a familiar object for a long time until new aspects were discovered. This exploration was also applied in class. When a pupil showed boredom or could not make a choice for a particular activity, the teacher invited the pupil to observe longer until something to do was found.

Figure 4. Discovering unseen things in familiar surroundings. The complete case is described by Looijenga et al. (2017a).

Figure 5. Observing a familiar object for a long time.

2.2.2. Discovery behaviour of the pupils

Each task was simply and clearly verbalised and demonstrated by the teacher. During the joint activities, all pupils were actively participating in a quiet and attentive way. Individually, the pupils reacted adequately and started discovery behaviour on interaction between pupil and teacher about the subject.

2.2.3. Conclusions

The situation was familiar and did not require unmastered skills. Each task was doable and challenging, because of the detailed description of the unusual criteria for successful observation such as "observe until you are no longer bored". The explorations were a great success in starting discovery behaviour. From this case we learned that even these young pupils are capable of a lot more than we think. Through practice, they became skilled in broad application of detailed observation, resulting in a calm approach of all sorts of tasks.

In short; the beneficial characteristics of the structure of the task were:

- giving a simple task,
- working towards skillfulness,
- including precise criteria for successful observation.

2.2.4. Next question

The results showed that practice can change inability in ability. But is a simple task in a familiar situation sufficient to start discovery and invention? Or is additional intervention of the teacher required?

2.3. Case study 3: Wheels at work

2.3.1. The task

The issue of this design assignment was about wheels and leverage. A week before, a demonstration was given of lifting a weight from the floor, hanging at the end of a rope. First, the teacher was standing on a chair, so that the rope was longer. Then, the teacher was standing on the floor and the rope was shortened. Forty pupils (6 to 9 year olds) explored hands on a circuit with "machines" searching for answers to the question "What requires more effort; lifting a weight on a long rope or on a shortened rope?".

The same assignment was given three times.

The first time, the "machines" in the circuit were simple, e.g. cork screw, pulleys, K'nex, windlass. The second time the "machines" in the circuit were complex, e.g. waterwheel, windmill, pinwheel, music machine. The third time the children had to make a self-created "machine".

Figure 6. Simple machines

Figure 8. Self created machine

Figure 7. Complex machine

Because an aim of this study was researching the effect of handling without teacher intervention, there was no intermediate evaluation at the end of each lesson.

The complete case is described by Looijenga, Klapwijk, De Vries (2017a)

2.3.2. Discovery behaviour of the pupils

The task was quickly clear to all students. It appeared that all pupils found a starting point for their search. Even generally passive pupils started exploring without any encouragement from the teacher. They started their exploration with a familiar object, a corkscrew or hand drill. After this groundwork, they kept on going. We learned that even passive pupils would reach an active discovery state by providing them with household objects and by giving them time to discover.

Both circuits evoked in all pupils' active exploratory behaviour.

The success of making self-created "machines" in the third period was relatively poor.

2.3.3. Conclusions

The results clearly show the positive effect of a simple and challenging task, accompanied by a familiar situation. The task was specified by the demonstration and the accompanying question. The familiar situation activated all pupils to discover and try fresh ideas. However, the absent evaluation led to this striking detail: the pupils did not develop spoken language. They showed insight by means of actions and gestures, not words. Another effect of the absent joint evaluation was the relative failure of making self-created "machines". Apparently the pupils had a fuzzy view of what the teacher expected of them.

This proves that intervention by the teacher towards shared reasoning and shared language is necessary to take a next step in discovery and invention. The lack of a teacher's intervention in the third period of the activity led to the prevention of the onset of designing, because shared language is required to build clear expectations.

In short; the beneficial characteristics of the structure of the task were:

· giving a simple and challenging task

· focusing on a familiar situation

2.3.4. Next question

The results showed that clear expectations are important for carrying out a task. In this case, the expectations appeared to be vague in the last period due to the lack of shared language. Expectations can be vague, but they can also be too complex. When pupils lack analysis skills, they are incapable of handling complex expectations of the teacher. How can we practice analysis skills?

2.4. Case study 3: The thinking hats

2.4.1. The task

The thinking hats of De Bono were chosen as an instrument to handle analysis. The six different coloured hats are connected to specified views on a subject. We used the factual, positive, negative, emotional and creative points of view to practice the rules and means of expression on a cuddly toy. The teacher had the overall view and scaffolded the use of specific language, accompanying specific hats. This was done by repeated use of specific words when inviting pupils to tell about the cuddly toy. When expression got stuck, the teacher always asked the same questions (More? Another hat?) to help the pupil to keep on going. The pupils themselves decided how much and in what way they spoke about the cuddly toy.

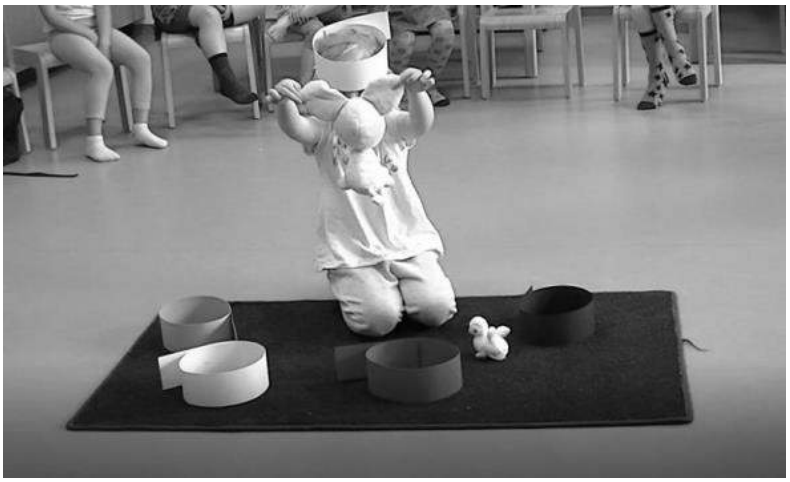

Figure 9. De Bono's thinking hats

The case encompassed three periods: demonstration, practice for camera with an unfamiliar cuddly toy and after that with a familiar cuddly toy. See Looijenga, Klapwijk, de Vries (2017b) for a complete description of the case-study.

2.4.2. Discovery behaviour of the pupils

The task accompanied by scaffolding language supported the pupils in becoming expressively and verbally informative. The hats provided a structure that enabled the pupils to get and express varied ideas about their familiar cuddly toy. A structure in which other complex subjects could be discussed, was set.

At the start familiarity with analysing with the hats and the accompanying words was poor. Nevertheless, during the third period, some pupils reached such a level of analysing that they started to discover and to invent new ideas.

2.4.3. Conclusions

The task to tell about the cuddly toy from one specific view, suggested by a hat, was unambiguous. The object was familiar. The challenge was analysing the subject from specific points of view with accompanied verbalisation. During practicing, both mastering of and familiarity with all points of view were growing for all pupils.

The results show that the level of familiarity with the cuddly toy affected the clearness of the point of view. The unfamiliar cuddly toy and the class cuddly toy evoked expression of uncomfortable feelings. Scaffolded, the pupils managed to express themselves clearly and class developed shared language about analysis using different perspectives (the five De Bono hats).

In short; the beneficial characteristics of the structure of the task were:

- giving a simple task,
- scaffolded working toward skilfulness,
- including unambiguous criteria for successful analysis

3. OVERALL CONCLUSION

To answer the central research question: The four cases show that a task allowing pupils to learn through discovery is based on:

- Simplicity of the task
- Familiarity of the situation in which the task is performed (including all required skills!)

And defined by:

- Simple and clear criteria for a successful performance of the task

Together these characteristics ensure a clear view on the task.

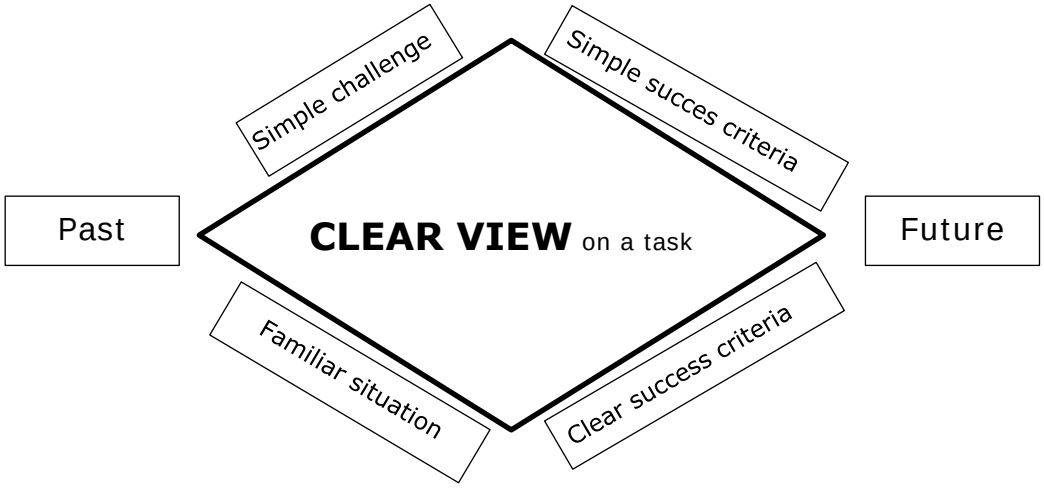

Figure 10. Task-structure supporting a clear view

4. DISCUSSION

4.1. Limitations

These case-studies took place on a Montessori school with a tradition of valuing pupil's autonomous behaviour. When pupils are not used to autonomous acting, they might need adaptation of tasks or separate rehearsal of skills furthering autonomous behaviour.

4.2. Implications

Recently, a lot of attention has been paid to the value of clear and simple success criteria due to the work of Hattie (2012), and Black and Wiliam (2009) on formative evaluation.

The notion of doability has been less central lately, but not less important. To resolve the dilemma of offering a challenge and avoiding unfamiliarity, Dewey (1938) recommends to build on existing knowledge and experience. A familiar situation encompasses knowledge and skills. Sennett (2009) points out the significance of specific abilities within a task. Unfamiliarity with specific abilities, needed to accomplish the task, can lead to frustration and passiveness. Through the adaptation of the learning situation it is possible to build on pupil's experiences as well as to promote positive skills and dispositions (Creative Little Scientists, 2014).

The simple structure can be used by teachers on the fly during their design and technology lessons as well as elsewhere. Whenever teachers observe that pupils are not attentive and active during task performance, they can conclude that a clear view is absent and use the structure to find out the cause of the passiveness. Do the pupils have the required abilities, does the task include a doable challenge, do they know what to do?
Currently there are many good Design and Technology lessons on the market, but they have the format of one big procedure. This format creates confusion for teachers. We concluded that attentive and active pupils are the result of an appropriate supply of tasks. This implicates, that a complicated project needs a split into several doable tasks. Support from teaching methodology designers can help teachers to achieve this. Therefore further research into possibilities for abovementioned support might be useful.

5. REFERENCES

Black, P., Wiliam, D. (2009). Developing the theory of formative assessment. Educational Assessment, Evaluation and Accountability, 21(1), 5-31. DOI: 10.1007/s11092-008-9068-5

Clarke, S. (2001). Unlocking Formative Assessment. London: Hodder and Stoughton

Creative Little Scientists (2014). Recommendations to Policy Makers and Stakeholders. ISBN: 978-960-473-516-7. Retrieved from: http://www.creative-little-scientists.eu/

Dewey, J (1910). How We Think. Mineola, NY: D.C. Heath & Co, Publishers

Dewey, J. (1938). Experience and Education. New York, NY: Kappa Delta Pi.

Gopnik, A. (2012). Scientific thinking in young children: Theoretical advances, empirical research and policy implications. Science 337(6102), 1623-1627 doi: 10.1126/science 12223416.

Hattie, J. (2012). Visible Learning for Teachers. New York, NY: Routledge.

Hayes, J.C., Kraemer, D.J.M. (2017). Grounded understanding of abstract concepts: The case of STEM learning. Cognitive Research: Principles and Implications, 2(7). doi 10.1186/s41235-016-0046-z.

Kimbell, R. (1994). Tasks in Technology. An Analysis of Their Purposes and Effects. International Journal of Technology and Design Education 4, 241-256. doi: 10.1007/BF01212805.

Kirschner, P.A., Sweller, J., Clark, R.E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. Educational Psychologist, 41(2), 75-86. doi: 10.1207/s15326985ep4102 1.

Looijenga, A., Klapwijk, R.M., de Vries, M.J. (2015).The effect of iteration on the design performance of primary school children. International Journal of Technology and Design Education 25(1), 1-23. doi: 10.1007/s10798-014-9271-2.

Looijenga, A., Klapwijk, R.M., de Vries, M.J. (2017a). Groundwork: Preparing an effective basis for communication and shared learning in Design and Technology Education. Design and Technology Education: An International Journal 21(3). Retrieved from: https://ojs.lboro.ac.uk/DATE/article/view/2157.

Looijenga, A., Klapwijk, R.M., de Vries, M.J. (2017b). Initiation of verbal expression in young children in Design and Technology education: a case study. Australasian Journal of Technology Education 4. Retrieved from: a http://dx.doi.org/10.15663/ajte.v4i1.47

Lemke, J. L. (2000). Articulating communities: Sociocultural perspectives on science education. Journal of Research in Science Teaching, 38(3), 296-316

Mercer, N. (2013). The social brain, language, and goal-directed collective thinking: A social conception of cognition and its implications for understanding how we think, teach, and learn. Educational Psychologist, 48(3), 148-168. doi: 10.1080/00461520.2013.804394.

Montessori, M. (1912). The Montessori method. New York, NY: Frederick A. Stokes Company.

Papert, S., Harel, I. (1991). Situating Constructionism. Constructionism 36, 1-11. New York, NY: Ablex Publishing Corporation

Pirttimaa, M., Husu, J., Metsärinne, M. (2017). Uncovering procedural knowledge in craft, design,and technology education: a case of hands-on activities in electronics. International Journal of Technology and Design Education 27(2), 215-231. doi: 10.1007/s10798-015-9345-9.

Sennett, R. (2009). The craftsman. London, England: Penguin Random House.

Vygotsky, L.S. (1978). Mind in society. Cambridge, MA: Harvard University Press.

Zohar, A., & Dori, Y. J. (2012). Introduction. In A. Zohar & Y. J. Dori (Eds.), Metacognition in science education: Trends in current research (contemporary trends and issues in science education, 40) (pp. 1–19). New York: Springer.