UNIVERSITY OF TWENTE

Novices' Reasoning Processes in a Psychological Modeling Task

Bachelor Thesis Psychology

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Abstract

This study investigated novices' reasoning processes during a psychological modeling task. Subject of the experiment have been ten psychology novices. The task was to model a psychological phenomenon, called 'visual search'. Data was gathered by the think aloud technique. Correlations were found between the reasoning processes and between the reasoning processes and the other activities of the participants. Spearman's Rho yields a significant negative relation between orientation and evaluation. These findings are not in line with former research on modeling. In conclusion it can be stated that the reasoning process during modeling is a complex matter with many interactions. This needs further investigation, particularly with a view to the quality of the models, so that implications for practice can be concluded.

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1. Introduction

1.1 Modeling in science education

1.1.1 What is modeling?

In the most general sense, modeling is the process of creating a model. A model is anything used in any way to represent anything else. Some models are physical objects, for instance, a toy model which may be assembled, and may even be made to work like the object it represents. The closer the model resembles the phenomenon, the better the phenomenon can be understood (Gregg & Simon, 1967). There are many ways of representing models – for instance conceptual models, which may be drawn on paper, described in words, or imagined in the mind. They are used to help us know and understand the subject matter they represent. Modeling can especially help students build their understanding of complex problems such as those appearing in science education. There are different types and scopes of conceptual models.

Conceptual models range in type from the more concrete, such as the image of a familiar physical object, to the formal and abstract of mathematical models for which no visual representation is possible. The goal of a mathematical model is to capture the key relations between variables describing the modeled system, and if possible, to simulate the dynamic pattern to explain the outcomes.

"All models are wrong but some are useful." George E.P. Box

People's cognitive abilities are limited, particularly if the gathered information is complex. Modeling supports working memory and clarifies interrelations, which would otherwise not be captured. In the process of modeling real live systems or problems get reduced to their essence. This abstraction is necessary for the modeler to be able to concentrate on the critical elements and work effectively toward a solution (Greeno and Simon, 1984).

Models are often used for the support of reasoning processes such as prediction, sometimes with help of computer simulations, sometimes just imagined in mind, in which case we can speak of mental modeling (Gentner & Stevens, 1983) or mental simulation. When simulating, using computers or mentally, modelers should expect some surprises in the simulations. Indeed, if surprises occur modelers have to reconsider and rework their models do adapt to the reality or the other way round get another viewpoint and reinvestigate the system which is modeled. Even if simulations may turn out to be the very opposite of what we expected. These surprises are the key to improved understanding.

An abstract model can be conceptual, as a model in the mind, or physical, with an external representation (Webb, 1993) or both. It is important to admit that the activity of creating a model is not necessary conscious. If knowledge is acquired and memorized during an implicit, unconscious process, even the structure of the mental model could be not conscious as well (Bliss 1994). In this study the focus is on the explicit and conscious process of producing an external model. These external representations provide a useful tool in the everyday life of students.

There are of course some differences in the implementation of modeling tasks. It could range from a rather passive to a highly self-directed active process. In some cases the student gets an existing model and should try to understand it. This is mostly a passive process and the aim for the students reasoning process is rather small (Penner, 2000). The student engages in a more active process, if simulations are possible. According to Penner, a more effective learning approach is during experiments and demonstrations. Even a more deeper and self-contained knowledge acquisition process takes place when the model is self-created. This can be perfectly caught with an active modeling process in which explanation and understanding are mutually involved (Holland, 1998). Thus self-directed active modeling increases the knowledge and especially understanding. Learning sessions could be enriched with this process. The students' thinking could also change, because they have available a tool to work with scientific phenomena. That makes it easier to think about scientific topics in general as well (Stratford, Krajcik, & Soloway, 1998). This constructivistic educational approach is favored by temporary scientists; it is also called inquiry learning (for an overview see de Jong and van Joolingen, 1998). The participants in this study generate their models by themselves, which is thus a variation of inquiry learning.

Thus the importance of modeling in educational science is undoubted. Many researchers support this view (Sins et al., 2005; Stratford et al., 1998; Holland, 1998; Zimmermann, 2000). Modeling can be divided into subprocesses based for example on the learning circle of Löhner, van Joolingen, Savelsbergh & van Hout-Wolters (2005). Löhner et al. constructed a coding scheme which includes orientation, hypothesizing, experimenting, model implementation and model evaluation as reasoning processes, and actions and regulations as other activities. Subcategories for example of orientation are defining variables, domain talk, experience knowledge, theoretical knowledge and refer to instruction. Model evaluation for example is split into two subcategories: interpretation of the model output and evaluation of the model (see Appendix B for the whole scheme). This definition besides many others makes it possible to analyze and qualify the modeling approach.

1.1.2 Quality of different modeling approaches

Quality in a sense of efficiency is here seen as the ratio of the effective or useful output to the total input in any system. Referring to this particular study it means to have on the one hand a model which serves its purpose (as a teaching or learning device) and on the other hand a modeling process which is accomplishable and learnable. Since the modeling process can be described more in detail, scientists are able to say what a better approach is and what the account of the process is. In other words, what underlying techniques does a student need to use to get a good output, that is, a well-structured model? Findings by a study of Van Joolingen and De Jong (1993) state, that more hypothesizing during model generation leads to better models. Most studies into modeling focus on science education. In this study we are interested if these results also apply to other domains of science.

In a study of Sins, Savelsbergh and van Joolingen (2005) suggestions are offered to tackle the difficulties novice modelers have during the initial phases of modeling. They found that students were less successful in understand the coherence of subject matter when they primarily use a bottom-up approach. Students who are employing this approach to modeling do not consider how local model revisions impact the behavior of the model as a whole. The more successful students employed a top-down approach to modeling, in contrast, which involves students considering interactions between variables in their model when revising their model (cf. Sins, Savelsbergh, van Joolingen, 2005).

If further studies are able to replicate these findings we are more and more able to create a better learning environment for students.

Further Sins et al. say that students should be scaffolded to develop these more productive approaches to modeling, in which they learn to reflect on the impact of dependencies between variables on the dynamic behavior of their model. When students are introduced to modeling, it is argued that the top-down approach could be scaffolded by offering an expert model in order for them to productively model a certain phenomenon (cf. Sins, Savelsbergh, van Joolingen, 2005).

1.1.3 Problems with modeling

As it is clear what the goals of modeling are, the need to explore the obstacles which anticipate these goals arises. Modeling, as a high demanding reasoning process, is prone to different kinds of missteps. Individual differences can lead to different modeling strategies. Some of these strategies might be poorer and lead to less favorable models, which represent the science subject not adequately. Teacher support can have an important role in such situations. But to know what to tell teachers further results on this topic are needed. Some researchers have studied in this direction so. Findings of these studies are not pointing in the same direction. For example, van Joolingen en de Jong found that more hypothesizing while modeling leads to better models. Whereas other research has shown product evaluation and hypothesis generation to be important activities in reasoning processes, Elshout-Mohr et al. (1998) and Masui and de Corte (1999) stress the importance of evaluation in knowledge construction. Also it is pointed out that the orientation phase is crucial for good modeling (Stellmacher, 2009). Further research is needed to allocate the proper tendency for this effect in the current context.
For students it might be difficult to produce a good model, which aids the development of scientific knowledge. There are some indications that the way to present the modeling task to the student evokes counterproductive behavior. An example is puzzle-solving behavior. A factor that might stimulate puzzle-solving behavior is the presence of a system simulation. Because students in a study with a computer based inquiry learning modeling task had the "correct" data available, they spend their effort trying to match their model output to the system simulation output, rather than trying to explain the underlying mechanism (Löhner et al, 2005). In order to produce more pure results and to assure that not just reproducing takes place while model establishing, no physical model simulations are given in this study. Conceptual drawings, which are made by the participants of this study, are a variation of a physical model. Specifically, elaborative,

strategic activities such as drawing lead to the construction of a mental model (Kintsch, 1994). Empirical evidence that drawing improves learning (Van Meter & Garner, 2005) is consistent with the assumption that modeling leads to deeper understanding. However no physical simulation is given in this study, the simulation of the modeled system takes place in the mind of the modeler. According to Ainsworth, accurate drawings are a direct product of accurate comprehension. With more challenging materials, however, drawing may facilitate comprehension and learning (Ainsworth, 2006). Thus drawings such as those produced in this study are representations of mental models and therefore should aim comprehension.

1.2 Research question

The scope of education is the mediation of knowledge and skills. Especially scientists of the field of learning psychology have an interest in the details of the learning process. The importance of models and modeling in scientific education is shown above. If learning sessions can benefit from model and modeling, it should be known how students use these processes. Psychology is furthermore the central domain of cognitive research and uses models frequently to explain theories. Since it is vital for psychology to construct models, it would be interesting to investigate the process of modeling.

With more knowledge researchers and teachers could provide more efficient help for students during modeling tasks. Until now studies have been concerned with the research of reasoning strategies during modeling tasks in specific domains. But the domain of psychology is virtually neglected. A learning situation has to be simulated and the basic question is therefore how novices behave during the modeling process.

Accordingly is the research question of this study:

'What are the reasoning strategies of psychology novices during modeling a psychological domain?'

2. Method

2.1 Participants

Ten psychology novices participated in the study, all second and third year students of psychology at the University of Twente. Seven of the ten participants were women and three were men. All of them had already attended basic courses in cognitive psychology, so they were familiar with the research topic, but not experts.

2.2 Materials

The modeling task was derived from a psychological experiment called 'visual search'. The theory behind the experiment is the feature integration theory of attention (FIT) considered by Anne Treisman (1980). According to this theory, different kinds of attention are responsible for binding different features into consciously experienced wholes. In a search task this means, the more features distracters have in common with the target the longer it takes to find the target object. The students had access to the experimental task and thus could experience the tasks from the viewpoint of an experimental subject. The task was provided by an interactional learning environment of the University of Twente, called ZAPs (Hulshof, Eysink, & de Jong, 2006). The instructions included in addition to the theory and background information also the influential variables. The task for the participants was to explain the difference in reaction time by making a model. The instructions also included two training tasks. One puzzle to train the think aloud technique and one small modeling task to get to know the required form. Paper and pencil were used to build the models, which seemed to be more practical compared to a computer program. Everything what the participant said during the modeling task was recorded with a microphone. The experiment material can be found in Appendix A.

2.3 Procedure

The experiment started with a short introduction on modeling and information about the aim of the study. The participants started with the two small exercises, practicing the think aloud technique and making models. After that, they went over to proceed the ZAP experiment. It was a small simulation of the phenomenon that needed to be modeled later in the experiment. It should give the participants a feeling of the construct they were about to work with. Then they started with the modeling task without a time constraint. The experiment ended as soon as they stated that they could not think of any model improvements.

2.4 Data collection and analysis

The think aloud protocols were split into text segments and were coded in different categories based on the scheme created by Löhner et al. (2005). The first main category, scientific reasoning, has five sub-categories: orientation, hypothesizing, experimenting, model implementation and model evaluation. The second main category, other activities, has four subcategories: actions, regulation, off tasks and experimenter. The complete coding scheme can be found in Appendix B. Participant 7 needed to be excluded from the remaining analysis because of a different model outcome; she made a concept map instead of a conceptual model. A second rater coded the text segments of participant four as well. The interrater reliability of the main categories was good (Cohen`s kappa = 0,82). The mean time in percent of the single categories was computed as a moving average and graphs of the strategies' process curves were plotted. The moving average were obtained by first taking the average of the first five percent. The five percent is then shifted forward, creating a new subset of numbers, which is averaged. This process is repeated over the entire modeling process. The plot line connecting all the (fixed) averages is the moving average. The moving average is not a single number, but it is a set of numbers, each of which is the average of the corresponding five percent of the whole modeling process. (For example, a 10-day simple moving average (SMA) of closing price is the mean of the previous 10 days' closing prices. If those prices are pM, pM-1, pM-9 then the formula is $SMA = \frac{p_M + p_{M-1} + \cdots + p_{M-9}}{10}$. The percentage of time was placed on the X-axis, the percentage of shared processes on de Y-axis. This yields an overview when which reasoning process in which amount was utilized.

In order to find differences between the participants, the models were ranked. The model drafts were rated on the basis of an ideal model Appendix D. The ideal model would deserve 18 points without the subtraction of one of the five possible minus points. Scoring criteria were both the number of used variables and the relationships between these variables. Thus wrong relations between variables lead to more negative classification of the model. In order to find regularities between the activities of the participants and the quality of the model a correlation matrix were made for the particular reasoning processes and the order from worst to best model.

3. Results

3.1 Reasoning processes

To be able to compare the reasoning processes participant 7 has to be excluded. She made a concept map instead of a conceptual model which was ask for in this study. Table 1 shows the percentages of time for each of the reminding participant and category. The time the participants needed varies from 6 minutes to 25 minutes and 30 seconds. Almost all participants spent 2/3 of the time on scientific reasoning and the 1/3 on other activities. Just participant 10 spends a noticeable larger percentage of his time, but this probably due his especially short worktime of 4:45 min. He spends 86,1 % on scientific reasoning and 13,9 % on other activities. Within scientific reasoning, the largest category is orientation with a mean of 28,5 % and is thus the largest category in all. There are partly large differences between the other categories beside orientation. For instance maximum/minimum time amount on hypothesizing is 36,1%/8,0% or on model evaluation it is 25,0%/5,3%.

Percentage of time participants spent on reasoning processes

Participants	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**	**10**	**Mean**
Scientific Reasoning	54,7	56,8	51,9	71,4	59,6	69,6	59,2	76,6	86,1	65,1
Orientation	**34,7**	**33,3**	**24,1**	**35,7**	**25,8**	**30,4**	**29,6**	**23,4**	**19,4**	**28,5**
Hypothesizing	**8**	**12,6**	**14,6**	**19**	**13,5**	**21,7**	**15,5**	**18**	**36,1**	**17,7**
Experimenting	**4**	**0**	**0,6**	**0**	**1,1**	**0**	**1,4**	**1,6**	**0**	**0,97**
Model implemention	**2,7**	**0**	**1,3**	**4,8**	**0**	**5,2**	**0**	**8,6**	**11,1**	**3,74**
Model evaluation	**5,3**	**10,8**	**11,4**	**11,9**	**19,1**	**12,2**	**12,7**	**25**	**19,4**	**14,2**
Other activities	45,3	43,2	48,1	28,6	40,4	30,4	40,8	23,4	8,3	34,3
Actions	**14,7**	**17,1**	**8,9**	**23,8**	**22,5**	**19,1**	**11,3**	**16,4**	**13,9**	**16,4**
Regulation	**24**	**23,4**	**31,6**	**4,8**	**13,5**	**4,3**	**11,3**	**4,7**	**0**	**13,1**
Off tasks	**1,3**	**0**	**0,6**	**0**	**1,1**	**0**	**2,8**	**0**	**0**	**0,64**
Experimenter	**5,3**	**2,7**	**7**	**0**	**3,4**	**7**	**15,5**	**2,3**	**5,6**	**5,42**
Total time	**17:00**	**15:00**	**25:30**	**6:00**	**13:15**	**19:15**	**7:45**	**11:30**	**14:45**	**14:31**
Points model	3	13	8	12	6	12	11	16	4	

Table 1

3.2 Modeling strategy

In order to find regularities in the strategy, a timeline was computed for the different processes. Figure a – i (Appendix C) show the participants` reasoning strategies. Some regularity was found. All subjects start with high orientation, which slightly decreases over time, but with recurring peaks. Near the end of the timelines there are little to no orientation at all. This is a relative robust pattern over all participants. Hypothesizing is not much less utilized, but a lot more complex to analyze. There is no regularity, but except for participant 9 strong ups and downs all over the timeline. Participant 10 shows extreme strong peaks compared to participant 1 where the level is always low without peaks. Beside the fact that also for implementation no regularities were found, these two activities are positively correlated. Experimenting is the least used activity by all participants. This effect occurs likely due to the setting of the modeling task. Löhner et al. (2005) described experimenting as following:

'Episodes about the design of experiments for the system simulation as well as for the students' model were scored in this category. The description of the output of either simulation was also coded as experimenting.'

In a paper and pencil study without the possibility to simulate actively (which would be the case with a computer program) it is obvious why this category has to be less present. All of the participants gathered information about the phenomenon with the given experiment material and the computer program called 'Zap'. The 'Zap' simulates the effect which should be represented but also explained with the model. No one of the participants used the 'Zap' again while modeling. If the participant experimented, there is just one peak (participants 6, 2, 10 and 4 do no experimenting at all; all of them, except participant 6 produced low scoring models). The better the model the earlier is the peak, but what is determining this effect is unclear. Evaluation correlates negatively with orientation (Spearman's Rho = -0.73, p = .025). The more time the participants investigated in orientation during the modeling task, the less time they evaluated what they were doing. Further can be seen that when orientation decreased, evaluation increased. That leads to peaks in the middle and in the end of the modeling task, except for participant 1 and 8 which have no peaks of evaluation in the end. Significant differences between other actions and between other actions and scientific reasoning were found.

Correlation matrix

	rank	orienta	hypothe	experi	imple	evalu	actions	regula	offtask
orienta	-,267								
hypothe	,150	,367							
experi	,305	-,096	-,522						
imple	,271	-,339	,729*	-,177					
evalu	,283	-,733*	,617	,044	,424				
actions	,067	,500	,083	-,339	,017	,033			
regula	,000	,317	-,883**	,383	-,712*	-,717*	-,267		
offtask	,188	,099	-,683*	,548	-,342	-,396	-,119	,693*	
experi	-,059	-,276	,100	,074	-,162	-,033	-,699*	,059	,085

Table 2 * significance at a 0,05 level)test two-sided) **significance at a 0,01 level (test two-sided)

3.3 Models

As a consequence of the differences found in the strategy analyses, the models were arranged according to quality. All models were rated by two raters. The interrater-reliability of the model scoring was nearly perfect (Kohen`s kappa 0,98). The produced models showed a wide range of detail and size. Finally four participants were assigned to the strong group (5, 8, 3 and 9) and five to the weak group (2, 10, 6, 1 and 4). The Man-Whitney-U test shows no significant differences between the two groups and any subprocess of scientific reasoning. Close to significance were the values of orientation and model evaluation. The correlation test between the reasoning processes yield some significant relations. But in the first place no significant results are found for the ranking order. A trend is that the strong group evaluated more and did less orientation than the weak group. For these finding no significance were found. Figure A and B shows the two models that were rated best and worst, as typical examples of these models.

Figure A

Best rated model

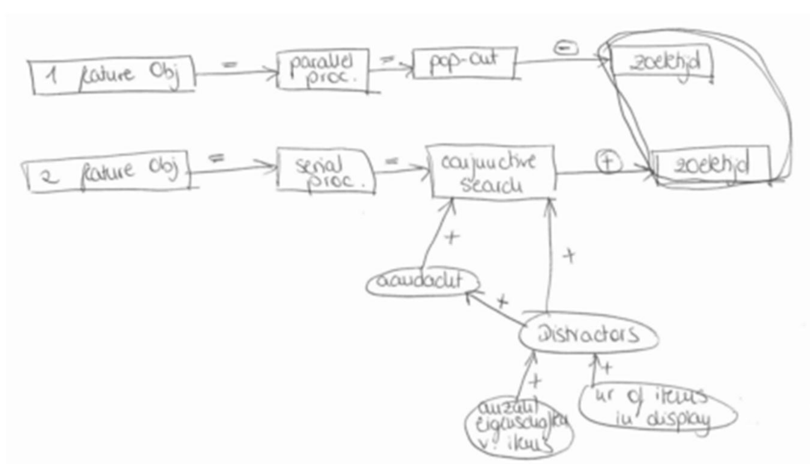
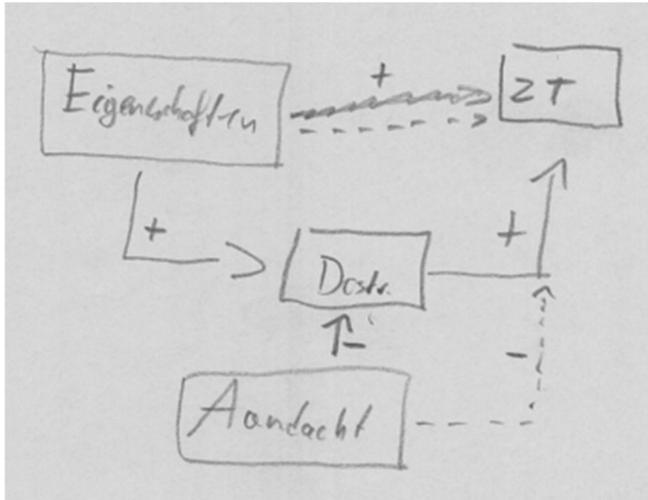


Figure B

Worst rated model



4. Discussion

The results of this study lead into two directions. On the one hand there are statistical significant relations found between some reasoning processes. The research question 'What are the reasoning strategies of psychology novices during modeling a psychological domain?' can not be answered definitely with these study results. But what can be found are trends with need of further investigation to verify or falsify. This is what is on the other hand, grounded on this results useful suggestions for further research can be made.

We were not able to find significant relations between the quality of the models and the strategies. Nevertheless the reasoning processes orientation and evaluation seemed to have the most impact on a model. The importance of orientation is supported by work by Van den Broek (2007). He studied modeling behavior of experts and novices in the domain of management. He found that experts spent more time on orientation than novices did. Maybe due to the fact that this study contained just novices the effect is blurred. Modelers, who evaluate more and oriented less, seem to have a better model than the ones who orientate more and evaluate less. Thus, novices seem to turn the effect found by Van den Broek (2007). Further investigation with novices is needed to clarify this relation. So far orientation is still seen as one of the most important processes during the task, because of its prevalent implementation by all modelers. If modeling is used in an educational setting with novices, the teacher should attend to the support of the evaluation of the model. An exception to the novices is participant 9 (best rated model). She seemed to have certain knowledge over the phenomenon on which the psychological theory is based. This could be an indication for the practical implementation of modeling. Modeling as an educational procedure should take place later in the learning process, when a certain amount of knowledge already is attained. Optimizing the support for students referring to orientation and the other categories can have considerable positive implications for science education in general.

As said before the value of a model or modeling process is a complex issue. The goal of a modeling task in a learning environment should be to help a student to internalize external knowledge. In this study the efficiency of the modeling task was only measured by ratings of the model quality in a sense of completeness. For a better grounded quality rating of models of different types further studies should test the learning effect of the modeling task as well. Another limitation is that processes may have taken place silently. If the participants had more time to learn the think-aloud technique more intensive, some of possible hidden processes could have been detected.

This study has to be seen as a pilot. For further studies in this research topic more participants are needed. Mainly to certify the trends which are found in the modeling strategies which lead to better models.

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Appendix A:

Experiment material

Beste proefpersoon,

Modeleren is een aanpak om fenomenen (of theorieën, ideeën, gedachten) te externaliseren. Door de onderliggende variabelen uit te vinden, in samenhang met elkaar te brengen en te schetsen ontstaat een externe representatie, die de structuur en de werking van een fenomeen verheldert. Op die manier kan men hypothesen afleiden, modellen testen of gewoon begrijpen hoe iets in elkaar zit. Het is een methode om leren en begrip te ondersteunen en te verdiepen.
Dit onderzoek wil de structuren van het modelleerproces uitvinden.

In het volgende zal je aan hand van een klein experiment en een theorie daarvan zelf een model maken, dat verbanden tussen variabelen verklaart. Het is de bedoeling dat je hierbij de hele tijd hardop gaat denken.

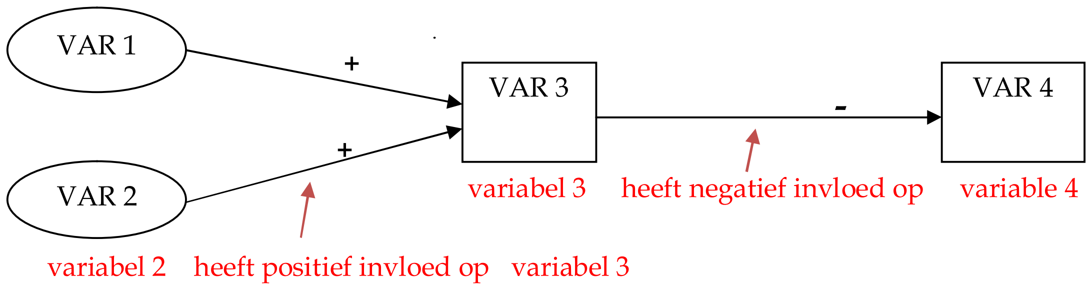
Voordat je met het modelleren echt gaat beginnen, krijg je twee kleine opgaven om het modelleerproces en het hardop denken te oefenen.

O**pdracht 1: Puzzel**
Maak uit de 4 puzzeldelen een vierkant. Probeer de hele tijd hardop te denk

Opdracht 2: Een lekkende emmer water
Onder een lopende kraan staat een wateremmer, dus er stroomt water in de emmer. Onderaan, op
de zijkant, heeft de emmer een gat waar ook weer water uitstroomt. Hoeveel water er door het gat
uit de emmer stroomt, hangt af van twee dingen. Ten eerste: hoe groter het gat, hoe meer water er
doorheen kan en ten tweede: hoe meer water er in de emmer zit, hoe groter de druk van de waterkolom, waardoor het water harder uit het gat zal stromen.

Modelleer de lekkende emmer water en probeer weer de hele tijd hardop te denken.

Voorbeeld van elementen in een model:



Theorie:
Je staat op het centraal station en komt een vriend ophalen. Er lopen echter tal van mensen van en naar de treinen en tussen de massa door probeer je je vriend te detecteren. Geen gemakkelijke opgave, tenzij je vriend een rode jas en een bolhoed zou dragen. In dat geval zou hij zeker opvallen tussen de vele andere mensen daar aanwezig. Je zou dan zeker niet veel tijd nodig hebben om hem te detecteren. In de psychologie wordt er dan gesproken van een **pop out effect**: het te identificeren item, je vriend in dit geval, kan snel gedetecteerd worden omwille van zijn opvallende kenmerken.
Maar stel je voor dat je je vriend in een treinstation in Engeland staat op te wachten, waar het vol loopt met 'gentlemen' met bolhoeden. De zoektocht naar je vriend wordt dan al een stuk moeilijker, want al die andere mensen met een bolhoed treden immers op als afleiders of **distractors**.

Je hebt in het experiment net kunnen ervaren dat deze distractors onder bepaalde omstandigheden meer verwarring veroorzaken in vergelijking met andere condities. Wanneer we zoeken naar een item met opvallende **kenmerken** (b.v. kleur, grootte, afstand tot andere items), kunnen we een zogenoemde **feature search** uitvoeren. Bij een feature search wordt de omgeving eenvoudigweg gescand op het kenmerk of de kenmerken waar we naar op zoek zijn. Er is hier vaak sprake van een **pop out effect** van het item. Distractors spelen in dit geval geen (grote) rol. Het te zoeken item springt er tussenuit, je zoekproces kan zodoende erg vlot verlopen. Sterker nog, omwille van de opvallende kenmerken van het te zoeken item, wordt het haast onmogelijk om het item te ontwijken op onze zoektocht.

Het wordt echter moeilijker, wanneer een item waar we naar op zoek zijn, geen opvallende kenmerken heeft. In zo'n geval moeten we een conjunction of **conjunctive search** uitvoeren: we zoeken dan naar een item dat een bepaalde combinatie (in het Engels: conjunction) van distractor kenmerken bevat. Het item valt daarom niet op tegen de distractors en het zoekproces zal bijgevolg langer duren. We moeten ook onze **aandacht actief** richten op het zoekproces, het item dat we zoeken springt immers niet boven de distractors uit.

Anne Treisman ontwikkelde een theorie, de **feature integration theory (FIT)**, om het gemak waarmee we feature searches en de relatieve moeilijkheid waarmee we conjunctive searches uitvoeren, te verklaren. Treisman stelt dat we een **mentale map** hebben waarin kenmerken

uit ons visuele veld gerepresenteerd zitten. Zo is er bijvoorbeeld een map voor elke kleur, grootte, vorm enz.
De representatie van deze kenmerken van een bepaald object in een map is:

a) onmiddellijk: er is geen bijkomende tijd nodig voor verdere cognitieve verwerking
b) gelijktijdig: alle kenmerken worden tegelijk gerepresenteerd
c) preattentief: er is geen gerichte aandacht voor nodig

Bij **feature searches** scannen we relevante **kenmerk-mappen** en kijken we of er elementen of items vanuit ons visuele veld in aanwezig zijn. Dit proces kan snel gebeuren en ondervindt relatief weinig hinder van het **aantal** elementen in ons visuele veld. Bij **conjunctive searches** is er echter een bijkomende cognitieve verwerking nodig. We hebben hier onze **aandacht** nodig als een soort mentale lijm om twee of meer kenmerken van een bepaald item te combineren. Het te zoeken item vertoont immers overeenkomsten met de overige items uit ons gezichtsveld. Enkel de kenmerken van 1 object kunnen tegelijk gecombineerd worden door onze aandacht. Hoe meer objecten of items in ons visuele veld aanwezig zijn, hoe langer het zoekproces zal duren.

Invloedrijke variabelen:
Zoektijd (snele feature search vs langzame conjunctive search)
Eigenschap van zoekobject („Featuremaps“: kleur, afstand, orientatie, grote)
Aandacht (process bewust of onbewust)
Distractors (aantal, eigenschappen)

Opgave:
Maak een model, dat de verschillen in de zoektijd kan verklaren. Probeer de feature integration theorie zo duidelijk mogelijk te maken, dat jij en andere het goed kunnen begrijpen. Maak het ook zo compleet als mogelijk en denk daarbij ook aan eventueel andere variabelen, die niet in de tekst staan of niet expliciet gekentekend zijn. De vorm van het model zou dezelfde zijn als bij de lekkende emmer water.
Vergeet ook het hardop denken niet.
Succes!

Appendix B:

Coding Scheme by Löhner et al. (2005)

Orientation
- Defining variables
- Domain talk
- Experience knowledge
- Theoretical knowledge
- Refer to instruction

Hypothesizing
- Predictions
- Hypothesis generation

Experimenting

Model implementation

Model evaluation
- Interpretation model output
    - Concluding
    - Describing
- Evaluation model

Other activities

Actions
- Model syntax
- Tool is not working
- Tool use
- Reading
- Calculating

Regulation
- Planning
- Choose activity
- Evaluation
- Task
- Frustration

Off task

Experimenter

Appendix C:
Figures

Figure a

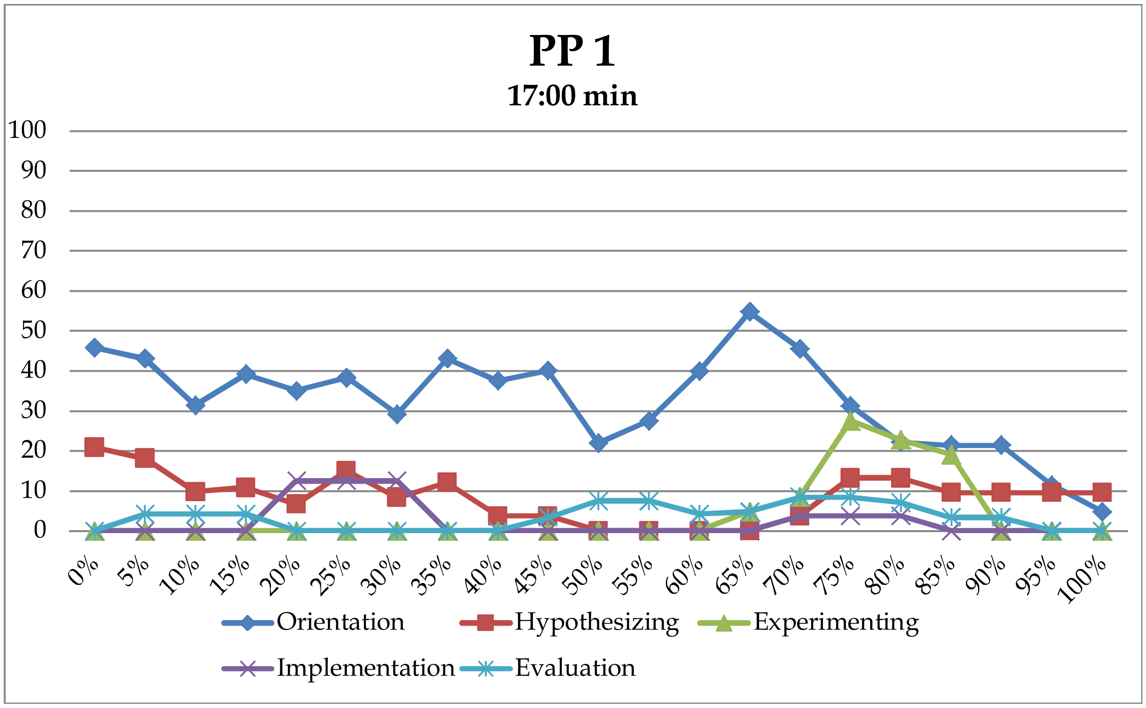


Figure b

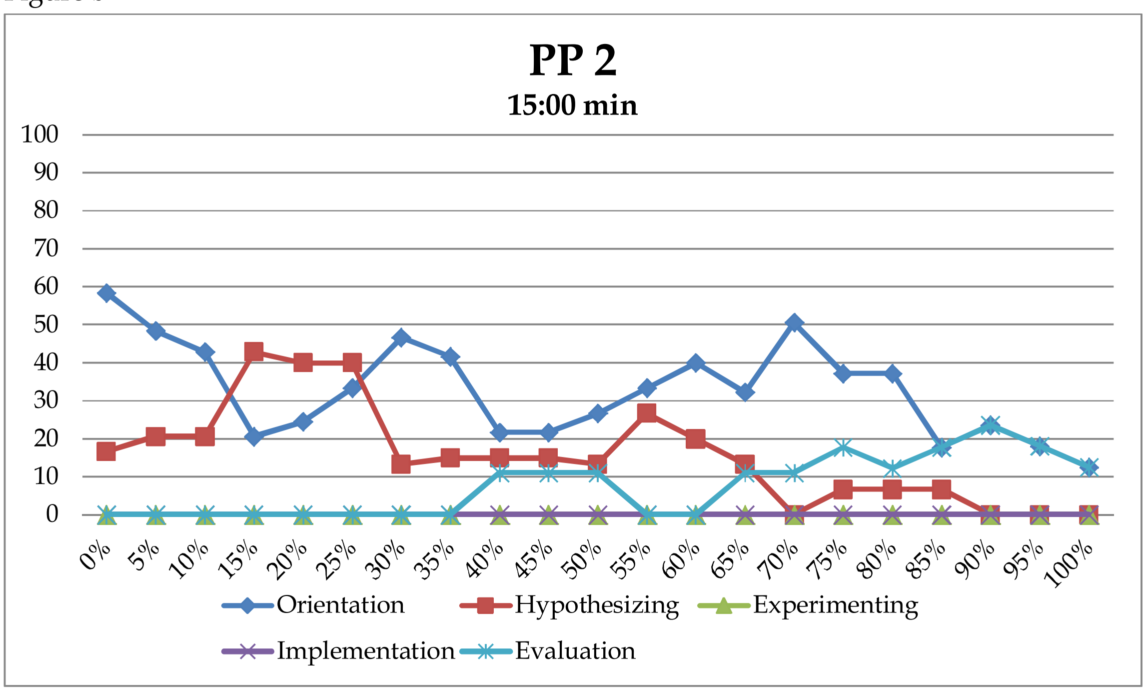


Figure c

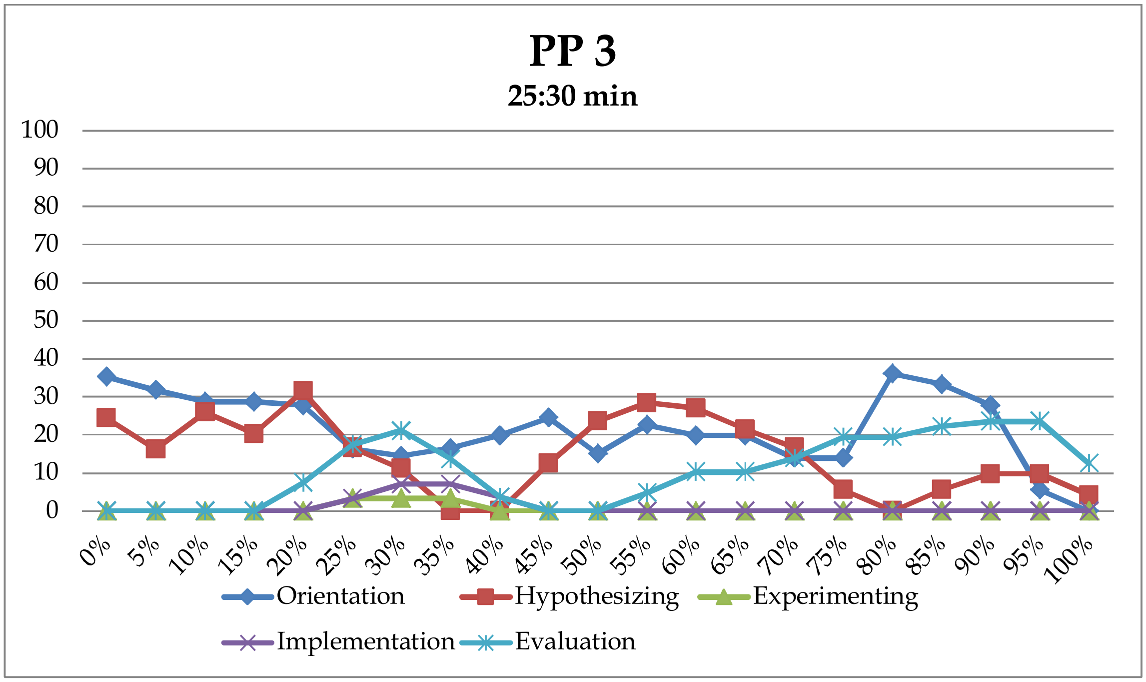
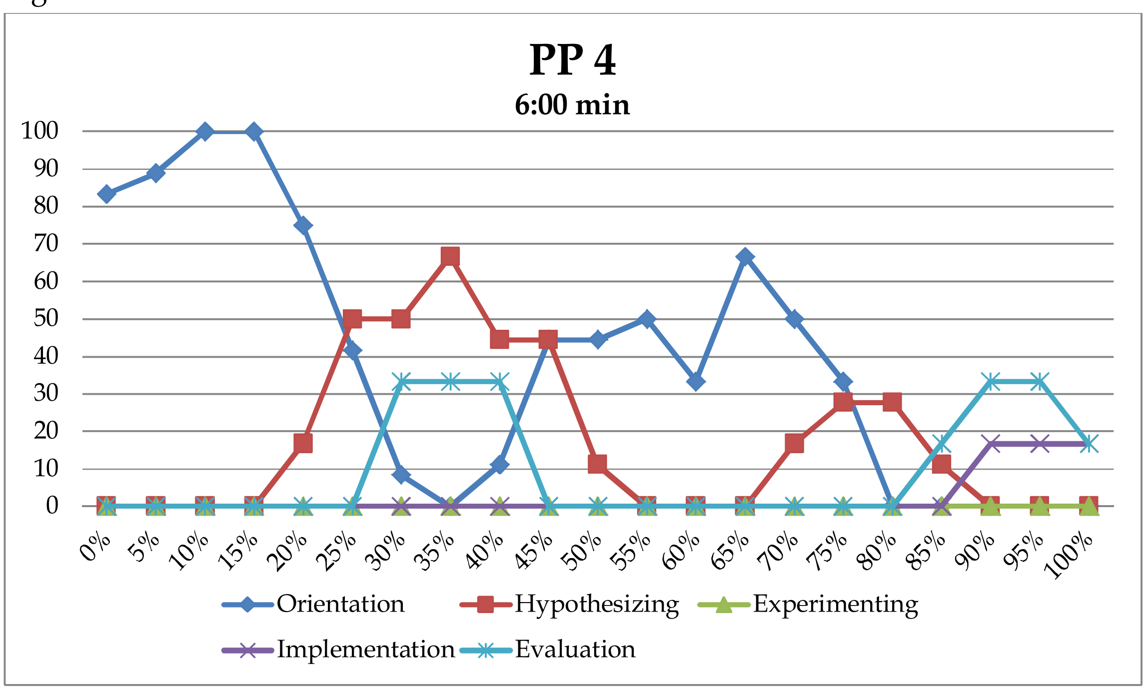


Figure d



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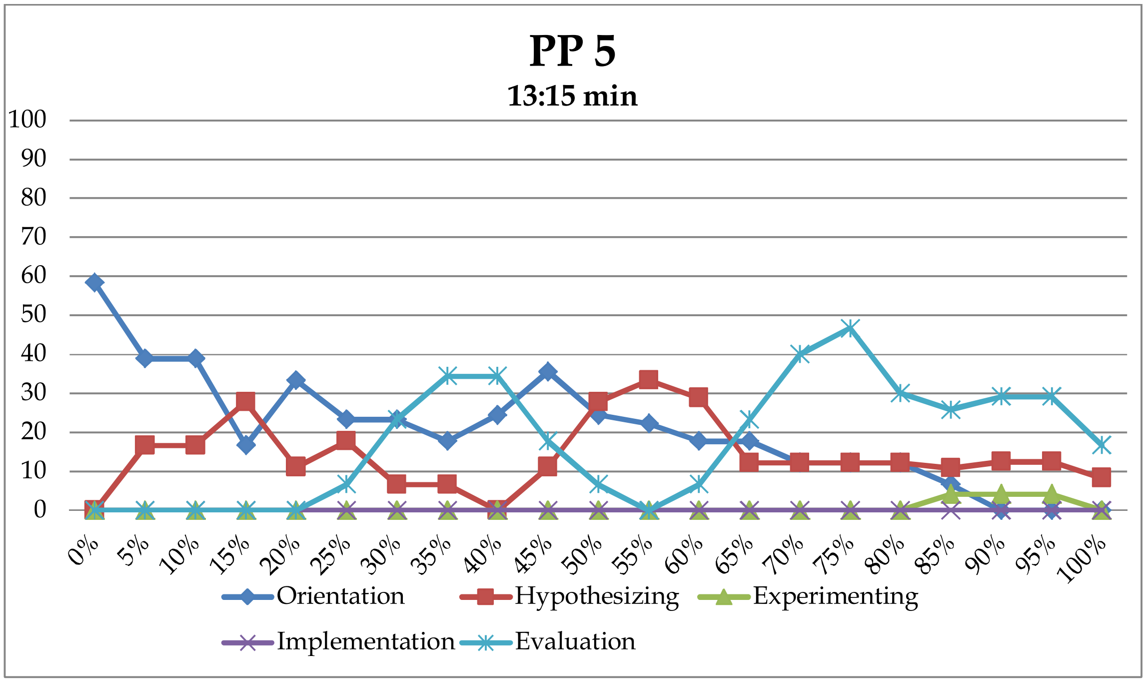
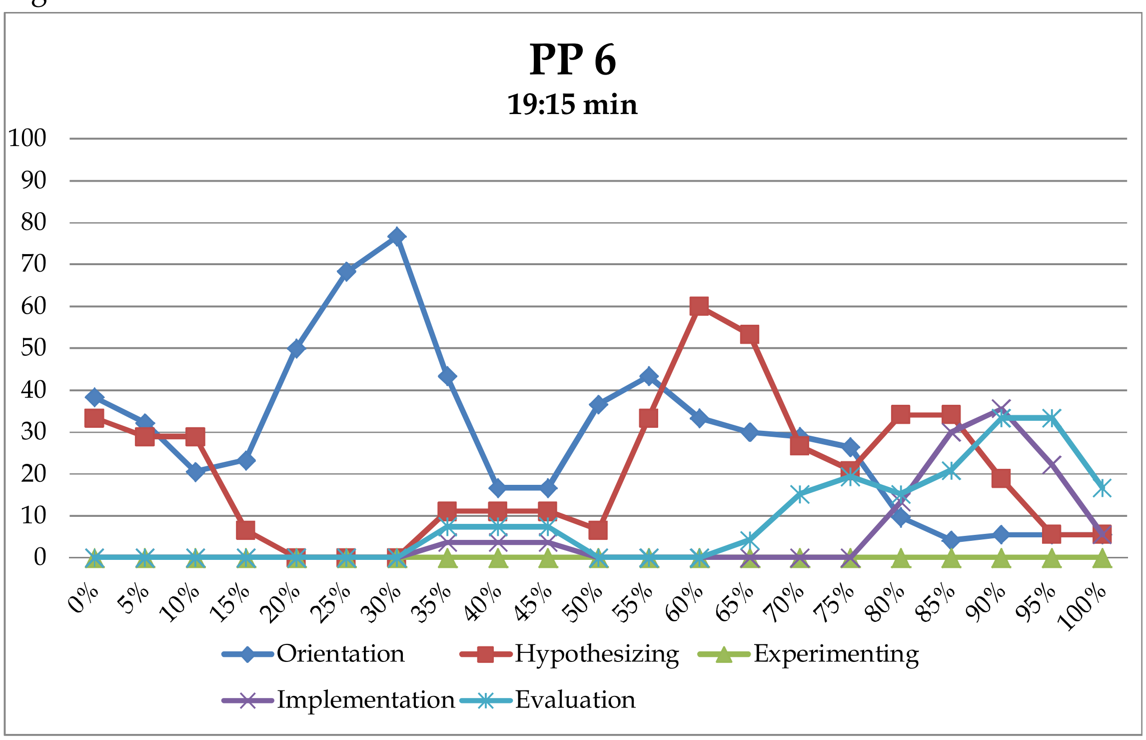


Figure f



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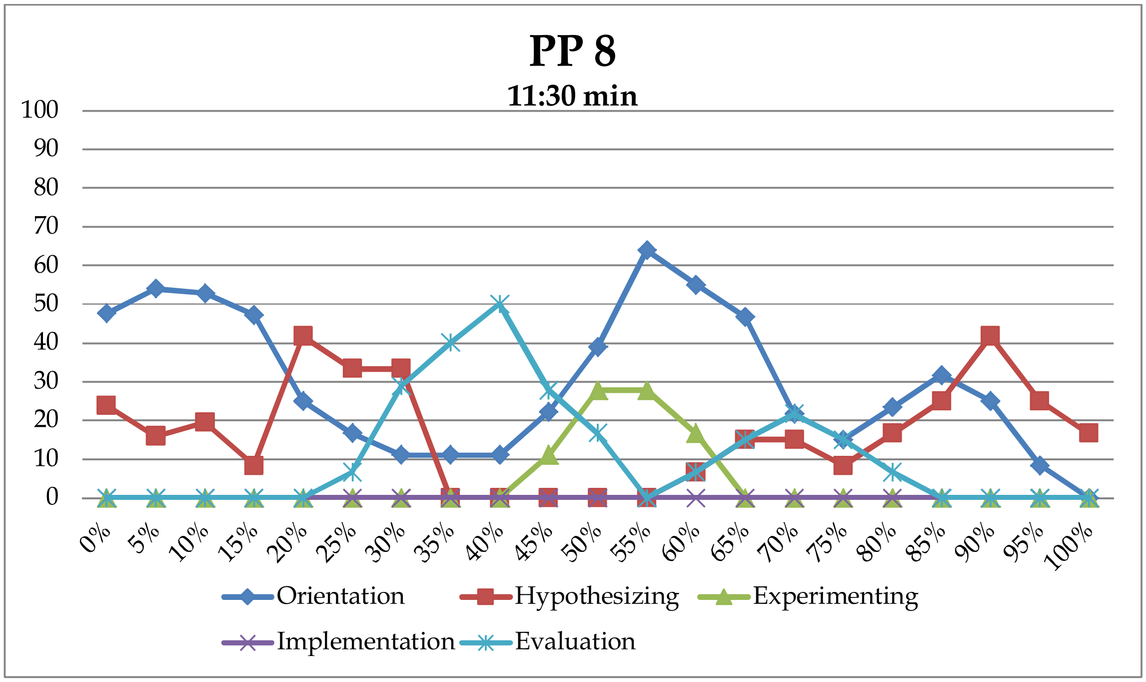


Figure h

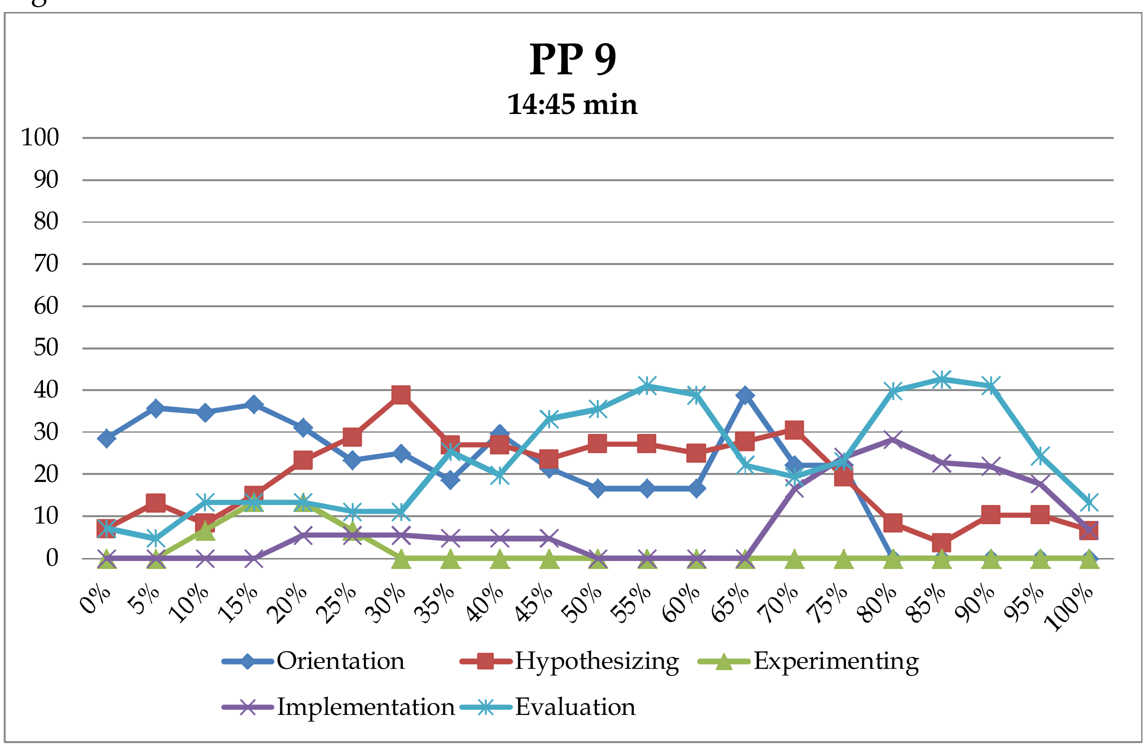
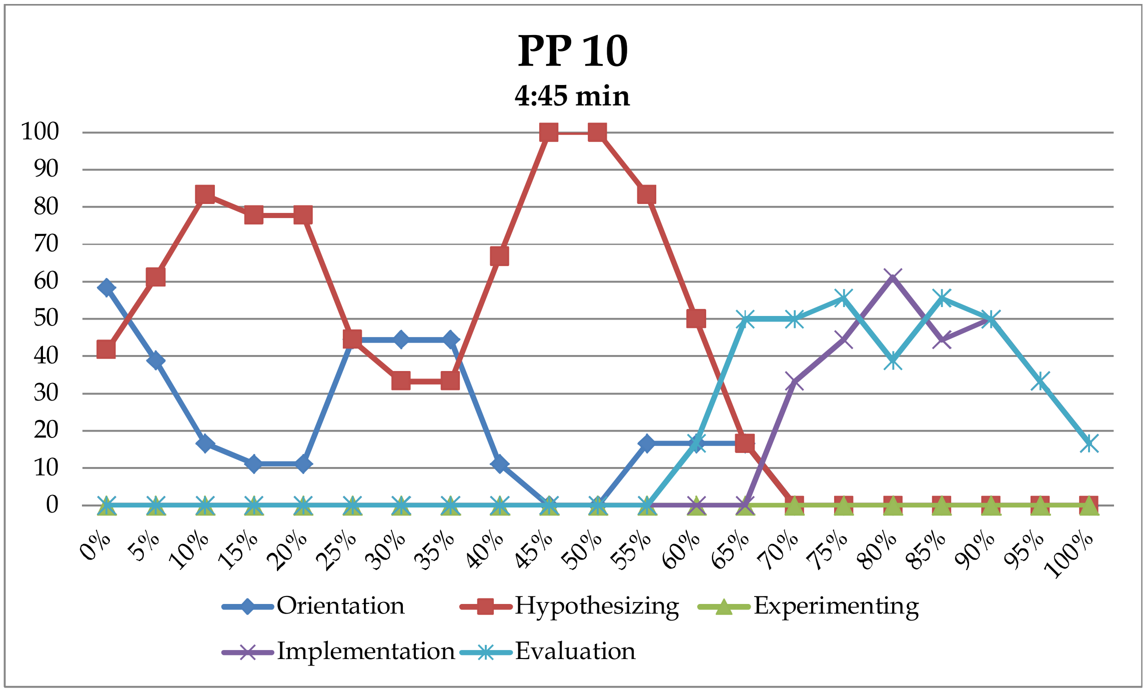


Figure i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Orientation
Hypothesizing
Experimenting
Implementation
Evaluation

Appendix D

Ideal model