The Effect of Nudges, Visual Literacy and Their Interaction on Enhancing the Understanding of Process Models

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Abstract

Visual information has several advantages over text. A process model consists of visual information. However, little is known about the contributing factors that influence the understanding of these process models. Visual literacy and nudges are two potential contributing factors to the ability to understand process models and reduce clutter. In this study, we researched by using an online questionnaire (N = 37) whether we could enhance the understanding of process models with the help of nudges, visual literacy and the interaction effects between the nudges and visual literacy. We executed a univariate ANOVA to compare the effect of the nudges on the understanding of process models with the two nudge conditions, visual literacy and all possible interactions as predictors. The results showed that nudges do not significantly influence the understanding of process models, which was not in line with our expectations. Visual literacy may have a significant influence, which aligns with our expectations. There was one significant interaction between visual literacy and the arrow nudge; however, not in the direction that we expected, therefore, not in line with our expectations. Given our small sample size, our significance could rest on a coincidence. We offer no open-and-shut conclusions about enhancing the understanding of process models with the help of nudges, visual literacy and the interaction effects between the nudges and visual literacy.

Keywords: *visualisation, visual literacy, process model, interaction, nudges, social psychology, psychology*

Contents

Introduction

Visual language has existed 25,000 years longer than written language (Moody, 2009). Visual information has several advantages over text: visuals require less effort to recognise, are easier to recall (Dewan, 2015) and are more powerful in expressing abstract knowledge (Schnotz, 2005). One way to visualise abstract knowledge is by the use of process models. However, little is known about the contributing factors that influence the understanding of these process models (Reijers & Mendling, 2011). It is an aspiration for the designer that process models are intuitive and easy to digest for people with different levels of knowledge and expertise; however, current practice shows that this is a challenging goal. Navigating the potential decisions to optimise a visualisation is complex and lacks sufficient research and knowledge at this time (Alhadad, 2018). Currently, there is little information available about which representation methods for visualisations are effective or efficient (Marchak et al., 1993). Additionally, which visual attributes are most helpful in conveying specific information is unclear. Applying specific visual dimensions within a visualisation is one of the essential factors for its comprehension. In this thesis, we will investigate if specific visual information, a nudge, will help the understanding of process models.

Visualisations are representations of complex information constructed in such a way that it is supposed to enhance understanding (Alhadad, 2018). Visualising data is essential to scientific practice to communicate crucial information to others in an understandable format. However, in companies where visualisations are used to convey essential information through process models, improvement is needed to achieve understanding within different levels of an organisation. According to Mulder (2019) comprehension of process models, in practice, is experienced as more of a problem on the employment level of C-level executives. A C-level executive (e.g. CEO, CFO, CTO) is a person who holds a senior position, plays a strategic role within the organisation, and impacts company-wide decisions. Visualisations are currently used to enable communication of information that is difficult to convey or too cumbersome to convey in words (Alhadad, 2018). One way to support understanding visualisations is using short textual captions. A short textual caption is an example of signalling. Signalling refers to using textual information to direct the attention within a visualisation to support the cognitive process of comprehension (Alhadad, 2018). That means that this information is inherently integrated with visualisations to provide context. Therefore, it is also essential to optimise coherence between the visualisation and the supporting text in ways that aid understanding.

So far, research points out that experts in business modelling are capable of understanding more complex process models, whereas novices are not (Reijers & Mendling, 2011). The capability to understand visualisations is measured by assessing people's visual literacy. Visual literacy is the ability and skill to read and interpret visually represented data in visualisations and extract information from them (Lee et al., 2016; Börner et al., 2019). Visual literacy is one of the essential basic skills people need to read process models. One potential reason why experts in business modelling are more capable of understanding complex process models has to do with their perceptive and cognitive capabilities. Human perception and cognition are generally pretty fallible and have limited capacity for processing information (Alhadad, 2018). In this study, we use a visual information modality instead of mainly textual information. Therefore, we limit the amount of information, which could make it easier to process. Another reason why experts in business modelling are more capable of understanding complex process models is that with prior learning of specific methods and patterns, they can rely on a more automatic retrieval of acquired information for understanding. These methods and patterns of prior learning suggest that a general conceptualisation of visual literacy may be shaped by education (Alhadad, 2018).

Although visualisations can improve reading and understanding of information, they can also lead to visual clutter. Visual clutter consists of either a shortage or excess of information or shortage or excess of visual properties in a graphical representation that results in a chaotic or high-density layout which creates visual complexity (Alhadad, 2018). Additionally, this can create a lack of an organised structure for representing the data. Visual clutter has been shown to increase errors in interpretation and judgement of cluttered visualisations. However, it could increase the confidence with which people make decisions and should therefore be avoided.

One of the approaches to avoiding visual clutter is chunking. Chunking refers to grouping elements into larger or broader units based on their meaning, learnt associations or cognitive skill set (Alhadad, 2018). In other words, segmenting complex visualisations into more manageable, meaningful chunks of information. There are different chunking strategies; in this thesis, we will focus on the perceptual chunking strategies. Perceptual chunking strategies include using common visual parameters like colour or shape (Alhadad, 2018). Consistent use in combining these parameters can strengthen the segmentation for more efficient cognitive processing. Careful consideration about how visual display elements can be grouped into meaningful psychological entities can support perceptive and cognitive capabilities. In this study, we will be using a nudge as a form of perceptual chunking strategy to attempt to make process models more comprehensive.

According to Thaler and Sunstein (2021) a nudge is any aspect of the choice architecture that predictably alters people's behaviour without forbidding any options or significantly changing their economic incentives. By adding nudges to process models, we attempt to enhance their understanding. Nudges work by targeting shortcuts within the brain when an individual needs to make a choice (Fyhri et al., 2021). These shortcuts are immediate and often automatically triggered. In addition, they have no consequence for an individual's rational choice. Nudges are based on the idea that certain choices are better for an individual in the long run than others, but only when people themselves agree with the goals represented by these choices (Venema et al., 2020). Therefore, nudges cannot be expected to change behaviours that people have strong opinions about. A strong preference in favour or against the nudged option makes the nudge ineffective. Nudges predictably influence choice behaviour and will only change contextual aspects that are presumably irrelevant (Fyhri et al., 2021). With that in mind, nudges cannot take away people's freedom of choice since nudges highlight the choice context rather than forcing a specific option. Although meta-analysis and systematic reviews consistently conclude that most nudge interventions are effective, careful estimations from these publications indicate that effect sizes are small (Venema et al., 2020). Based on this, Venema et al. (2020) conclude that nudges are particularly effective without a clear preference for a choice. Additionally, the nudge has the potential to reduce uncertainty about the choices to be made. Due to the observed lack of understanding of process models (Mulder, 2019) and the existing experiments executed to improve this understanding thus far (Gouveia et al., 2020; Pinto et al., 2020), we were triggered to research the benefits of nudges within the process models above changing the visual representation of the process model completely.

There are many ways a nudge can be designed; therefore, in our study, we will limit ourselves to two nudges to enhance the understanding of a process model: a colour nudge and an arrow-style nudge. We will test whether these two types of nudges affect the understanding of process models and whether they interact with visual literacy in predicting this understanding. We have chosen to use a colour nudge because the colour might make the nudge stand out from the rest of the surrounding information, making it more visually salient, which also might reduce the necessary cognitive effort needed (Fyhri et al., 2021). In addition, the colour used might have a distinct effect through colour association. The reason why we have chosen to use an arrow-style nudge is because arrows engage in the process of turning informational spaces into passages (Fuller, 2002). An arrow takes loose bits of information and turns this information into order. With this, we hope to bring order into the process models. Combining colour and arrow style nudges can strengthen the segmentation for more efficient processing. We will investigate four conditions: a condition without a nudge, a condition with the colour nudge, a condition with the arrow nudge and a condition with the combination of both colour and arrow nudges. By using two different types of nudges and investigating the four conditions, there is a potential to get more insightful results, which could also provide better directions for future research.

To our knowledge, there is no answer in the current literature on what factors will help people enhance their understanding of process models. Some people can read visual information better than others. In this study, we investigate if nudges will help the understanding of process models, which leads to our main research question: *Will a visual nudge enhance the understanding of process models?* Based on the literature discussed, we predict that a visual nudge will have a small, significant effect to enhance the understanding of process models. Another important factor in reading process models could be the influence of visual literacy, which we will address in our first sub-question: *Will a higher visual literacy enhance the understanding of process models?* Based on the literature discussed, we predict that a higher visual literacy will significantly enhance the understanding of process models. When a visual nudge and visual literacy both enhance process models, there is a potential that there is an interaction effect, which leads us to our second sub-question: *Will there be an interaction effect between a visual nudge and visual literacy on the understanding of process models?* Based on the hypothesis of our main and first sub-question, we aim to predict an interaction effect between visual literacy and the use of nudges: we assume that people who can read process models effectively are less dependent on the nudges for their comprehension. This study's results are essential to provide helpful recommendations for improvements in the design and interpretation of process models. In other words, we will attempt to minimise the noise in the visualised message from the sender to the receiver.

Method

Participants

In this study, 44 participants took part, of which 37 (N_{male} = 18, M_{age} = 24.24, SD_{age} = 9.68, range$_{age}$ = 18 - 77) finished the entire questionnaire and were included in the results. The following demographic data were collected: gender, age, the continent on which they were raised, highest or present schooling, their employed level, their employed branch and if they were colourblind.

The participants were recruited by Sona System, via e-mail, social media (i.e. LinkedIn) and in person. When recruited by Sona System, the participants from a social study at the University of Utrecht got half an hour of subject hours (*Proef Persoon Uren*) (PPU) from the university for participation. In the case of any other voluntary participant, there was a chance to win a coupon. The registration for the PPU and the coupon were separately recorded from the main questionnaire to keep the participants anonymous.

Instruments

This study measured two variables: visual literacy and the understanding of process models. We measured visual literacy with the Efficiency of Visual Literacy Scale (EVLS) (Kiper et al., 2012). We assessed the understanding of process models with a questionnaire designed for this study, which will be referred to as the Understanding of Process Models Scale (UPMS). Additionally, the different nudge conditions were presented within the UPMS.

Efficiency of Visual Literacy Scale

The Efficiency of Visual Literacy Scale is a scale developed by Kiper et al. (2012) to assess students' efficiencies of visual literacy. The original language of the questionnaire was Turkish. The questionnaire used in this research consists of all original 29 statements professionally translated to Dutch. The participants had to answer on a five-point Likert-like scale that had the following options from 1 to 5: "I can definitely not do (*Ik kan het absoluut niet doen*)", "I cannot do (*Ik kan het niet doen*)", "I can maybe do (*Ik kan het een beetje doen*)", "I can do (*Ik kan het doen*)", "I can very easily do (*Ik kan het heel gemakkelijk doen*)". The lowest score that the participants could obtain is 29, and the highest score is 145. Higher scores indicate higher efficiency in visual literacy. An example statement is "I find my way with the help of a map (*Ik vind mijn weg met behulp van een kaart*)". The internal consistency coefficient of the 29-item EVLS for students was found to be α = .94 in the research of Kiper et al.. Additionally, Kiper et al. found that a 29-item and 6-factor solution was theoretically and statistically compatible for this questionnaire. The complete questionnaire can be found in Appendix F.

Understanding of Process Models Scale

The Understanding of Process Models Scale (UPMS) is a questionnaire we developed for this study to assess how well people understand the information presented in a process model. The original language of the questionnaire is Dutch and consists of 10 questions and 6 process models. The participants had to answer multiple-choice questions with four possible answers per question; only one answer was considered the correct answer. The lowest score that the participants could obtain is 0, and the highest score is 13, where these higher scores indicate a better understanding of process models. An example question is “Where does the process model start? (*Waar begint het procesmodel?*)”. Additionally, there was one question where the participant had to put different process models in the best-predetermined order; each model in the correct position was considered a right answer and awarded one point. Because this questionnaire was designed for this study, and this is the first time using the questionnaire, we had an expert in process models look at the questionnaire before distributing it. With the help of this expert, we have established a form of construct validity. Additionally, with the creation of the questionnaire, we created different degrees of difficulty within the questions. This way, a higher score gets harder to attain, and thus this will make a greater distinction between people who understand the process models and those who do not, within the limited amount of questions. Additionally, we added textual information to specific models to support comprehension. The complete questionnaire can be found in Appendix G.

Nudges

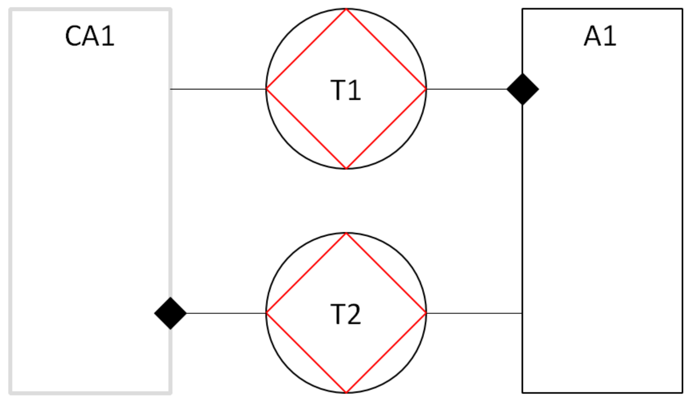
We used two types of nudges to enhance the understanding of process models: the colour nudge and the arrow nudge. As far as we have been able to find in the current literature, there has been no application of nudges in process models. Therefore, all our choices have been based on comparable (nudge) designs or associations and with the help and insights from experts in process modelling. In Figure 1, 2, 3 and 4 we show an example of the same process model used in the UPMS in the different nudge conditions we made. All other process models for the different conditions can be found in Appendix G.

First, with the colour nudge, we chose to use this nudge to determine where one could start the process model and how many times a specific element was activated during a single process instantiation. We chose the colour green for the start colour because this is a typical start colour in western society, i.e. starting lights at car races. To show how many times an element was activated, we used the colour orange and different hues of orange. An orange colour showed that the element was activated once, and a dark orange colour showed that the element was activated two times. A yellow colour showed that the element was activated under a specific condition.

Second, with the arrow nudge, we chose to use it to represent the sequence of the process model. The process model technique we used in this study was DEMO (Dietz & Mulder, 2020). The arrow nudge was derived from the process modelling techniques of Pronto (Noorman, 2008) and BPMN (Allweyer, 2016). With the visualisations of the arrow nudge, we try to bring some order into the sequence and apply those types of arrows as a nudge in the process models of DEMO to see if this would help.

Figure 1

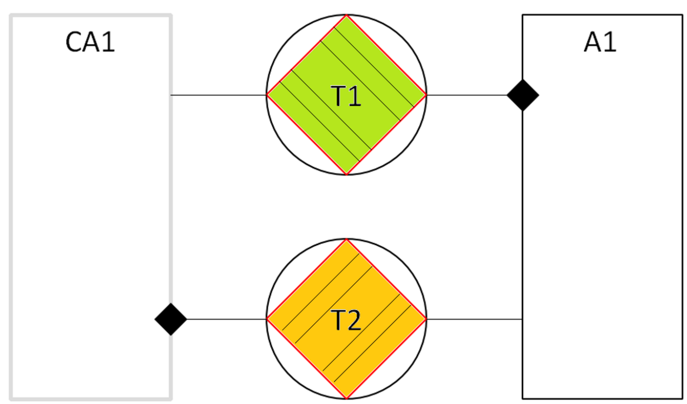
No Nudge Condition Simple Process Model



Note: The process model used in the no nudge condition of the UPMS

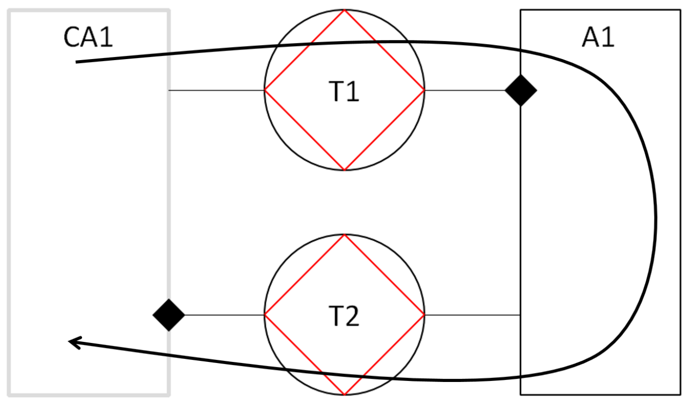
Figure 2

Colour Nudge Condition Simple Process Model



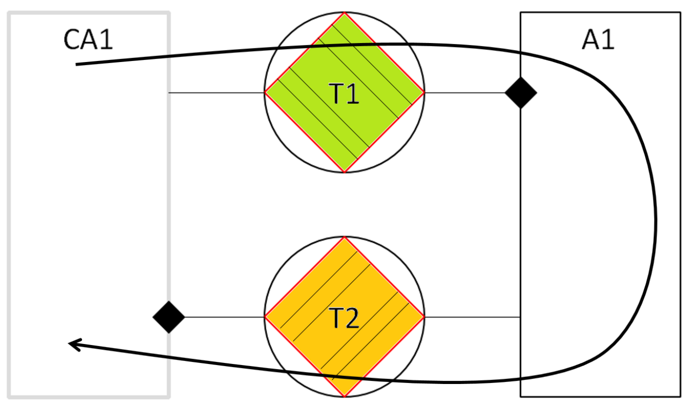
Note: The process model used in the colour nudge condition of the UPMS

Figure 3
Arrow Nudge Condition Simple Process Model



Note: The process model used in the arrow nudge condition of the UPMS

Figure 4
Arrow and Colour Nudge Condition Simple Process Model



Note: The process model used in the arrow and colour nudge condition of the UPMS

Procedure

The questionnaire was digitally administered in the program Qualtrics (2022). To start the questionnaire, the participants had to click the link. The participants were free to decide when and where to make the questionnaire. The study was introduced with a writing briefing, followed by informed consent, which can be found in Appendix B and C respectively. The questionnaire consisted of the Efficiency of Visual Literacy Scale (EVLS), the Understanding of Process Models Scale (UPMS) and the demographic questions.

After providing informed consent, the participants started with the EVLS, which contained 29 questions. Next, the participants got one of four conditions of the UPMS, each condition contained 10 questions. After completing the two questionnaires, they were presented with the demographic questions, which contained 7 questions. The demographic questions came last to prevent any negative feelings towards giving personal information or the feeling of providing personal information (Lietz, 2010). The study was concluded with a short debriefing where the participants were given some information about the conditions of the study and consequently thanked for their participation. The study was estimated to last about 20 to 30 minutes, but after about 10 participants, we changed the estimation to 15 minutes in the writing briefing based on the actual time participants spent on the questionnaire so far.

The debriefing and introductions to the questionnaires can be found in Appendix D and E respectively. The demographic questions can be found in Appendix H.

Data Analysis

The collected data was exported from Qualtrics (2022) and imported to IBM SPSS Statistics (Version 28) to be analysed.

We started by cleaning up the data (i.e. deleting incomplete questionnaires). Next, we requested descriptives of age and frequencies of gender and highest or present schooling. To check the distribution of the nudge conditions, we recoded the answers into dichotomous variables - 0 for a wrong answer, 1 for a right answer - and made a sum score for the different conditions. Consequently, we made a sum score for the entire Understanding of Process Models Scale (UPMS) independent of the condition the participant was in; this is our dependent variable. Additionally, we made a sum score for the Efficiency of Visual Literacy Scale (EVLS).

With the preliminary analyses done, we moved on to checking the assumptions. At all times, we kept in mind that $N = 37$. Six assumptions had to be met: measurement levels, linearity, absence of outliers, absence of multicollinearity, normally distributed residuals and homoscedasticity. For the sum score of the UPMS we created a standardised variable. We checked this variable for potential outliers; we determined an outlier as a case with a score of more than two standard deviations. This way, we identified two univariate outliers; one outlier more than two standard deviations above zero and one outlier more than two standard deviations below zero.

Next, the assumption of multicollinearity was not met. The Variance Inflation Factor (VIF) was too large, and multiple values were greater than 10; this did not meet the assumption. We solved this by creating a standardised value for the EVLS.

Now the VIF values were all under ten. The value of the sum of the EVLS for the Tolerance was smaller than .2, which might indicate a problem. However, because all other values were above .2, we did not consider this a problem. Consequently, the assumption of multicollinearity was met.

The Mahalanobis Distance indicated that we had one multivariate outlier with the calculated value applicable to our research. Adding that outlier to the two outliers determined by the standardised UPMS variable, brought us to three outliers total. We could remove the outliers to meet the assumptions of no outliers, but considering we have a small sample, this was more likely than in a big sample to impact the potential significance. Additionally, we did not have a priori reason to delete outliers. Therefore, we decided to run multiple analyses with and without the outliers to consider what kind of difference it might make to delete the outliers. In this, we consider two groups of outliers, the one multivariate outlier and the two univariate outliers. All other assumptions not commented on were met.

Consequently, we conducted a univariate Analysis of Variance (ANOVA) to compare the effect of the nudges on the understanding of process models with the two nudge conditions, visual literacy and all possible interactions as predictors. We used an ANOVA to help us understand how the different conditions potentially differ from each other. If we find statistically significant results, then the two conditions differ from each other. The Cronbach's alpha of the EVLS was calculated. The complete syntax can be found in Appendix I.

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Results

The Efficiency of Visual Literacy Scale (EVLS) was found to have a good internal consistency (α = .89) (Nunnally & Bernstein, 1994). To analyse the results for the understanding of process models with and without outliers, we created four models: the first model has all cases included, the second model has the multivariate outlier excluded, the third model has the univariate outliers excluded, and the fourth model has all outliers excluded. We executed the univariate ANOVAs for the four models. The univariate ANOVA revealed no statistically significant predictor in the first or second model. The Tables for those results can be found in Appendix A. In Table 1 and 2 we show the univariate ANOVAs to compare the effect of the nudges on the understanding of process models with the two nudge conditions, visual literacy and all possible interactions as predictors.

The univariate ANOVA of the third model revealed that there were statistically significant predictors. In Table 1 we show the Test of Between-Subject Effects of the ANOVA. With the two univariate outliers excluded, this model shows three significant results. The corrected model is significant (p = .036) with a large effect size (partial η^2 = .400) (Cohen, 1988). The ANOVA showed that the effect of visual literacy on the understanding of process models was significant (F (1,27) = 10.33, p = .003) with a large effect size (partial η^2 = .277). For a higher score on visual literacy, the participants score higher on the understanding of process models (B = .71). The ANOVA also showed that the effect of the interaction between visual literacy and the arrow nudge on the understanding of process models was significant (F (1,27) =5.37, p = .028) with a large effect size (partial η^2 = .166). The direction of the interaction effect between visual literacy and the arrow nudge on the understanding of process models was negative for the absence of the arrow nudge (B = -.36). This result means that the higher people score on visual literacy, the more they use the arrow nudge to enhance their understanding of process models. In addition, the lower people score on visual literacy, the less they use the arrow nudge to enhance their understanding of process models. The significant interaction effect from the third model is shown in Figure 5.

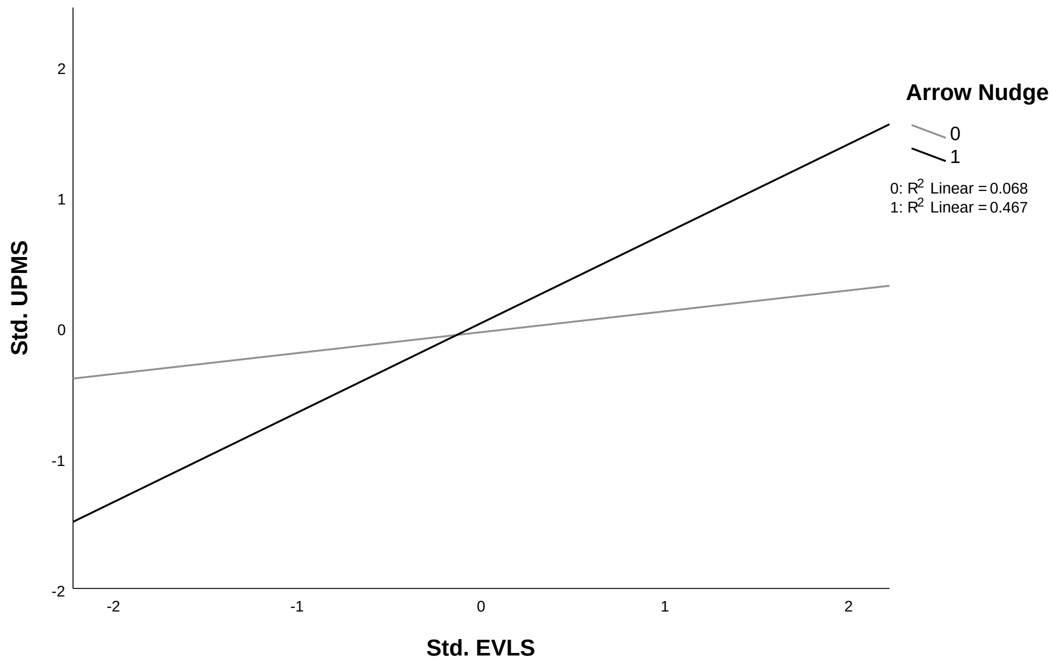
Table 1
Tests of Between-Subjects Effects: Univariate outliers (2) from std. UPMS excluded

Predictor	*SS*	*df*	*MS*	*F*	*p*	partial η^2
Corrected Model	19.990	7	2.856	2.569	.036*	.400
Intercept	801.738	1	801.738	721.319	<,001	.964
Colour nudge (cn)	6.11E-6	1	6.11E-6	0.000	.998	.000
Arrow nudge (an)	.591	1	.591	0.532	.472	.019
Std. EVLS	11.479	1	11.479	10.328	.003*	.277
Std. EVLS*an	5.963	1	5.963	5.365	.028*	.166
Std. EVLS*cn	.408	1	.408	0.367	.550	.013
cn*an	.085	1	.085	0.077	.784	.003
Std. EVLS*cn*an	2.290	1	2.290	2.061	.164	.071

Note: The tests of between-subjects effects of the ANOVA with the univariate outliers from the std. UPMS excluded. *SS* = Sum of Squares; *df* = degrees of freedom; *MS* = Mean Square; *F* = F-value; *p* = significance; partial η^2 = partial Eta squared; * = $p < .05$

Figure 5

Significant Interaction Effect Between Visual Literacy and the Arrow Nudge



Note: This figure shows the interaction effect between the standardised EVLS and the UPMS from the third model without the two univariate outliers. 0 = condition without the arrow nudge; 1 = condition with the arrow nudge

The univariate ANOVA of the fourth model revealed that there was a statistically significant predictor. In Table 2 we show the Test of Between-Subject Effects of the ANOVA. With all outliers excluded, this model shows one significant result. Visual literacy is a significant predictor (p = .012) with a large effect size (partial η^2 = .219) (Cohen, 1988). For a higher score on visual literacy, the participants score higher on the understanding of process models (B = .71).

Table 2
Tests of Between-Subjects Effects: All outliers (3) excluded

Predictor	*SS*	*df*	*MS*	*F*	*p*	partial η^2
Corrected Model	16.031	7	2.290	1.995	.095	.349
Intercept	560.650	1	560.650	488.317	<,001	.949
Colour nudge (cn)	.051	1	.051	0.044	.835	.002
Arrow nudge (an)	.740	1	.740	0.644	.429	.024
Std. EVLS	8.382	1	8.382	7.301	.012*	.219
Std. EVLS*an	4.649	1	4.649	4.049	.055	.135
Std. EVLS*cn	.559	1	.559	0.487	.492	.018
cn*an	.216	1	.216	0.188	.668	.007
Std. EVLS*cn*an	2.048	1	2.048	1.784	.193	.064

Note: The tests of between-subjects effects of the ANOVA with all outliers excluded. *SS* = Sum of Squares; *df* = degrees of freedom; *MS* = Mean Square; *F* = F-value; *p* = significance; partial η^2 = partial Eta squared; * = $p < .05$

Discussion

In this study, we researched whether we could enhance the understanding of process models with the help of nudges, visual literacy and the interaction effects between the nudges and visual literacy. To our knowledge, there was no answer in the current literature on what factors will help with comprehension. Because of our small sample size, we analysed four different models, depending on what cases we deleted as outliers, to consider the effect of deleting the outliers on the results. The first model contains all cases; in the second model, we excluded the multivariate outlier; in the third model, we excluded the univariate outliers; and in the fourth model, we excluded all previously determined outliers. When examining the four different models, we found that only the third and fourth models had significant predictors. Deciding whether to exclude outliers leads to conflicting results. In the paragraphs below, we will describe the interpretation of each of these results.

The sample size is the first thing we must consider when examining our results. Our sample consists of 37 complete questionnaires, 12.5% of what we needed, meaning that we do not have enough power in our analyses. Therefore, the results we have found could rest on a coincidence.

Firstly, we look at our main research question: *Will a visual nudge enhance the understanding of process models?* Based on the literature discussed, we predicted that a visual nudge would have a small though significant effect on enhancing the understanding of process models. We found no significant results in our four models for the effect of a visual nudge on the understanding of process models, meaning that a visual nudge does not enhance the understanding of process models based on these four models. This finding is not in line with our expectations.

Why would the nudges not significantly affect the understanding of process models? Besides our small sample size, different factors could influence the working of a nudge. This topic has typically been underinvestigated and systematic groupings of relevant features are currently lacking (de Ridder et al., 2022). Nonetheless, we have four potential reasons why the nudges did not significantly affect the understanding of process models. First, when a nudge is presented, people have to observe the nudge for the nudge to have any effect. It could have been possible that the participants had not observed the nudge; therefore, the nudge could not aid them in their comprehension of process models. It might help in future research to be transparent about using nudges to ensure people observe the nudges since transparency does not compromise nudge effects (de Ridder et al., 2022). Second, the nudge being presented is emphasising something; however, what it is emphasising concerning the answer options could be unclear to the people. If people do not relate the emphasis to the correct answer or not to any answers at all, then the nudges are not functioning as we would want them to. Therefore, nudges have less effect than anticipated. Third, we may have chosen the wrong nudges to enhance people's understanding of process models in this situation. There are many dimensions (e.g. spatial and chromatic) on which we can design a nudge (Marchak et al., 1993). Because we had to limit ourselves in this study, we selected two kinds of nudges. However, there is a possibility that a different kind of nudge works better than the ones we selected. Another possibility for a different kind of nudge could be a change within the dimension, i.e. using a different colour, or a change in the use of the dimension, i.e. using a nudge on the orientation dimension instead of the spatial dimension. Fourth and last, not only is the kind of nudge of potential influence, but the placement of the nudge could also be of influence. The placement of the nudge within the process model is related to the context. There is no neutral choice context; a new choice context or a change in the choice context may bring higher costs than leaving it be (Grill, 2014). Therefore, the nudge may have been placed in a position that changed the model so that it did not optimally support the comprehension. Even more so, the nudge may have added to confusion instead of comprehension because of this change in context. Considering these potential explanations, nudges could be significant on their own.

Secondly, we look at our first sub-question: *Will a higher visual literacy enhance the understanding of process models?* Based on the literature discussed, we predicted that a higher visual literacy would significantly enhance the understanding of process models. In the first and second models, we did not find a significant result for the effect of visual literacy on the understanding of process models. In the third and fourth models, we did find a significant result for the effect of visual literacy on the understanding of process models. Because of our small sample size, all our results could rest on a coincidence. On the one hand, our lack of finding significant results in the first and second models is contrary to our expectations. Visuals play a significant role in learning and performance and have to be planned and used purposefully to communicate the intended message (Aisami, 2015). A potential explanation for not finding a significant result could be that the process model was not designed in a way that it communicated the intended message. Therefore, it could be too difficult to read, regardless of whether people had a high visual literacy. Additionally, it could be that the scale we chose to measure visual literacy was not suitable for this situation. On the other hand, in the third and fourth models, we found significant results that were in line with our expectations. A potential explanation for finding significant results could be because of visual literacy itself. Visual literacy is acquired competencies for interpreting visual messages (Aisami, 2015). Visual literacy is one of the essential basic skills people need to read visuals (Lee et al., 2016; Börner et al., 2019). Therefore, this essential skill could explain the significant results found in the third and fourth models.

Lastly, we look at the second sub-question: *Will there be an interaction effect between a visual nudge and visual literacy on the understanding process models?* Based on the hypothesis of our main and first sub-question, we aimed to predict an interaction effect between visual literacy and the use of nudges: we assumed that people who can read process models effectively are less dependent on the nudges for their comprehension. The first, second and fourth models showed no significant interaction effects. This result was not in line with our expectations. The third model did show a significant interaction effect. However, this interaction was in the opposite direction of what we expected. We expected an interaction effect where people who score higher on visual literacy are less dependent on the visual nudges for their understanding of process models. However, the interaction effect showed that people who score higher on visual literacy profit more from the arrow nudge for their understanding of process models. Therefore, this result was not in line with our expectations. A potential explanation for these results could be that the type of nudges we used had no relation to visual literacy.

Furthermore, in the third model, the corrected model shows an explained variance of partial η^2 = .400, which means that the corrected model explains 40% of the variance for the understanding of process models. According to Cohen (1988) this is a large effect. Venema et al. (2020) described with careful estimations that the effect sizes of nudges are small; therefore, we expected a small effect within this study. Since we did not find a small effect but a large effect in the third model, we have to wonder why we found this large effect. A potential explanation for this finding concerns the significance found in the predictors of this model. We did not find any significant nudging predictors. However, we did find a significant result for the visual literacy predictor and the interaction between visual literacy and the arrow nudge, suggesting that the high explained variance is due to visual literacy, not the nudges. This assumption is also confirmed by the explained variance of the visual literacy predictor, which also has a large effect (partial η^2 = .277).

The following methodological limitations could have affected this research. First, as mentioned earlier, our sample size was 37 participants. The sample size needed we have calculated by using G*Power (Version 3). According to those calculations, we needed 295 participants when calculating with an effect size of 0.05. Our sample size turned out to be 12.5% of the sample size we needed to collect based on the calculations of G*Power. Despite the significance of the third model, because of the small sample size (N = 37), we cannot claim any power. Therefore, the significance found in the third model could rest on a coincidence.

Second, the amount of highly educated students (HBO and WO) in the sample (≈ 83%) is disproportionate the to actual population (≈ 24% (Centraal Bureau voor de Statistiek, 2021)) in the same age group. Because of this enormous difference, it becomes more challenging to generalise and accurately picture the current results. Additionally, this could mean that results could be more skewed towards the top scores due to the high schooling in the current sample than they would be if the sample were more representative of the schooling level of the population in the Netherlands.

Third, the sample comprises only people with an employment level under C-level. In Mulder (2019) it is stated that the comprehension of process models is, in practice, experienced as more of a problem on the employment level of C-level. A C-level executive (e.g. CEO, CFO, CTO) is a person who holds a senior position, plays a strategic role within the organisation, and impacts company-wide decisions. With this sample, we cannot state conclusions about the people who function on a C-level.

Fourth, we used a form of self-report (questionnaire), using the Efficiency of Visual Literacy Scale (EVLS), to attain the results. Questionnaires rely on truthful responses from participants to draw meaningful conclusions (Van de Mortel, 2008). When participants do not answer accurately, they may believe the answer they report is accurate (self-deception) or may 'fake good' or 'fake bad' (Van de Mortel, 2008). Thus, there may be socially desirable response bias in the results of the EVLS which could mean that the results are potentially more skewed towards higher scores on the EVLS in this sample because people want to believe or present that they are good at visual literacy.

Fifth and last, we used multiple choice answers in the Understanding of Process Models Scale (UPMS). Using multiple-choice answers could increase the chance of correct answers without the participant knowing the answer. In other words, there is a 25% betting odds of getting the correct answer. We could have applied a correction for betting odds; however, due to time restrictions, we did not. We choose multiple choice instead of open questions because open questions are harder to interpret.

This study's results are essential to provide helpful recommendations for improvements in the design and interpretation of process models. We have no open-and-shut conclusions about enhancing the understanding of process models with the help of nudges, visual literacy and the interaction effects between the nudges and visual literacy. However, despite no open-and-shut conclusions, we are more optimistic about future research and have a better direction. Therefore, we recommend further research on enhancing the understanding of process models. Firstly, we recommend more research into the workings of nudges and more focus on which factors determine whether nudges will influence people in general (de Ridder et al., 2022). This research is essential because, as mentioned before, this topic has been underinvestigated and is currently lacking. Secondly, a potential next step in this research is to look at both quantitative and qualitative evidence (Alhadad, 2018). To talk with people, ask them what they think is needed to enhance the understanding of process models. This way, we could get more insight into the reader's experience. Thirdly, we recommend that in future research, we investigate whether schooling groups other than HBO and WO arrive in jobs that require the kind of visual literacy needed with reading process models. When researching this, we can discern if people in higher education are the more important group when it comes to enhancing process models. Lastly, Alhadad (2018) claims that the importance of education in shaping visualisation and visual literacy cannot be understated. With the potential significant result from visual literacy and the large effect size, this could be an important direction in general. Therefore, in future research, one can give more attention to visual literacy in education.

In future research, we recommend addressing the following methodologically concerns. First, we recommend more focus on collecting a representative sample; this will hopefully create results that can be generalised and show an accurate picture of the situation. Second and last, in contrast to self-report, a different form of data collection of visual literacy might yield more evident results, leading to less potential bias.

In conclusion, we can only speculate on the results whether we could enhance the understanding of process models with the help of nudges, visual literacy and the interaction effects between the nudges and visual literacy. As such, this study does not provide enough reliable results to claim anything. Therefore, we advise that more research is needed to produce reliable results.

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A ANOVA Tables

Table 3

Tests of Between-Subjects Effects: All cases included

Predictor	*SS*	*df*	*MS*	*F*	*p*	partial η^2
Corrected Model	21.100	7	3.014	1.435	.230	.257
Intercept	887.413	1	887.413	422.577	<,001	.936
Colour nudge (cn)	.130	1	.130	0.062	.805	.002
Arrow nudge (an)	5.382	1	5.382	2.563	.120	.081
Std. EVLS	4.368	1	4.368	2.080	.160	.067
Std. EVLS*an	3.542	1	3.542	1.687	.204	.055
Std. EVLS*cn	4.403	1	4.403	2.097	.158	.067
cn*an	1.483	1	1.483	0.706	.408	.024
Std. EVLS*cn*an	4.984	1	4.984	2.373	.134	.076

Note: The tests of between-subjects effects of the ANOVA with all cases included. *SS* = Sum of Squares; *df* = degrees of freedom; *MS* = Mean Square; *F* = F-value; *p* = significance; partial η^2 = partial Eta squared; * = $p < .05$.

Table 4

Tests of Between-Subjects Effects: Multivariate outlier (1) from Mahalanobis Distance excluded

Predictor	*SS*	*df*	*MS*	*F*	*p*	partial η^2
Corrected Model	17.148	7	2.450	1.129	.373	.220
Intercept	605.215	1	605.215	278.987	<,001	.909
Colour nudge (cn)	.004	1	.004	0.002	.965	.000
Arrow nudge (an)	4.525	1	4.525	2.086	.160	.069
Std. EVLS	3.466	1	3.466	1.598	.217	.054
Std. EVLS*an	2.896	1	2.896	1.335	.258	.046
Std. EVLS*cn	3.490	1	3.490	1.609	.215	.054
cn*an	.589	1	.589	0.271	.607	.010
Std. EVLS*cn*an	3.886	1	3.886	1.791	.192	0.60

Note: The tests of between-subjects effects of the ANOVA with the multivariate outlier from Mahalanobis Distance excluded. *SS* = Sum of Squares; *df* = degrees of freedom; *MS* = Mean Square; *F* = F-value; *p* = significance; partial η^2 = partial Eta squared; * = $p < .05$.

B Writing Briefing

In deze brief wil ik u vragen of u wilt deelnemen aan het wetenschappelijk onderzoek voor mijn master scriptie. Het onderzoek zal online plaats vinden door middel van een vragenlijst. Dit onderzoek is getoetst en goedgekeurd door de Facultaire Ethische Toetsingscommissie (FETC) van de Faculteit Sociale Wetenschappen van de Universiteit Utrecht en voldoet aan de ethische richtlijnen.
Meedoen aan het onderzoek is op vrijwillige basis en u kunt te allen tijde stoppen zonder dat u hiervoor een reden hoeft op te geven. Voordat u beslist of u mee wilt doen aan het onderzoek, informeer ik u hieronder wat het onderzoek inhoudt en welke vragen u kunt verwachten. Deze informatie kunt u rustig doorlezen en neem gerust contact op via de e-mailadressen onderaan mocht u nog vragen hebben.

Opzet/uitvoering van het onderzoek

U krijgt een vragenlijst voorgelegd die bestaat uit drie delen. De drie delen zullen niet allemaal even lang zijn. In totaal zal het invullen van de vragenlijst ongeveer 15 minuten duren.

Achtergrond onderzoek

In dit onderzoek zal er met behulp van vragen over 'visual literacy' (visuele geletterdheid) gekeken worden hoe u procesmodellen leest. Hopelijk kunnen wij met behulp van deze gegevens in de toekomst de leesbaarheid van procesmodellen verbeteren om zo het begrip hiervan te vergroten.

Wat wordt van u als participant verwacht

Er wordt van u gevraagd om zo accuraat mogelijk te antwoorden. Het is van belang dat u de vraag goed leest en er goed over nadenkt vóórdat u antwoord geeft, zodat u niet per ongeluk een antwoord geeft dat niet uw bedoeling was. U kunt namelijk niet terug naar een vorige vraag wanneer u eenmaal naar de volgende vraag heeft doorgeklikt. Er zijn geen andere belastende eisen verbonden aan het beantwoorden van de vragen.

Mogelijke voor- en nadelen van het onderzoek

Wij verwachten niet dat er, buiten de tijd en energie die het u zal kosten, gevolgen zullen zijn bij het invullen van de vragenlijst.

Vergoeding/beloning

Wanneer u student bent aan de Universiteit Utrecht kunt u Proef Persoon Uren (PPU) verdienen met het meedoen van dit onderzoek. Onder de deelnemers die op vrijwillige basis meedoen aan dit onderzoek wordt een cadeaukaart van 25 euro verloot. Als u hier kans op wilt maken kunt u aan het einde van de vragenlijst uw e-mailadres achter laten zodat er contact met u kan worden opgenomen. Dit e-mailadres zal los opgeslagen worden van uw ingevulde data waardoor uw antwoorden niet tot u te herleiden zijn.

Vertrouwelijkheid verwerking gegevens

Wij gebruiken voor dit vragenlijstonderzoek het softwareprogramma Qualtrics. Deze programma's verzamelen de data op anonieme basis voor ons, en er worden geen IP-adressen verzameld. Verder worden in de vragenlijst of het experiment geen direct identificerende gegevens uitgevraagd.

Omdat het onderzoek anoniem wordt uitgevoerd betekent dit ook dat u uw gegevens niet kunt laten verwijderen. Wel kunt u uiteraard te allen tijde stoppen met de vragenlijst. De tot dan toe verzamelde gegevens kunnen dan eventueel nog wel worden gebruikt.

De ruwe data (onderzoeksgegevens) zullen voor minimaal 10 jaar bewaard worden. Dit is volgens de daartoe bestemde richtlijnen van de VSNU. Geanonimiseerde data van dit onderzoek zullen op termijn opgenomen worden in een open access database. Dit betekent dat ook andere onderzoekers deze data kunnen opvragen voor hun eigen onderzoek.

Vrijwilligheid deelname

Deelname aan dit onderzoek is vrijwillig. U kunt op elk gewenst moment, zonder opgave van reden en zonder voor u nadelige gevolgen, stoppen met het onderzoek.

Als u na het lezen van deze informatie besluit tot deelname gaat u akkoord door middel van het aanvinken van het vakje ‘Ja, de bovenstaande informatie is op mij van toepassing en ik wil meedoen met het onderzoek’. Daarna wordt u naar de online omgeving voor het invullen van de vragenlijst geleid.

Voor vragen kunt u terecht bij:

klachtenfunctionaris-fetcsocwet@uu.nl (klachtenfuctionaris)

i.mulder7@students.uu.nl (onderzoeker)

l.m.j.swinkels@uu.nl (begeleider)

C Consent Form

Hierbij verklaar ik de informatiebrief met betrekking tot het onderzoek gelezen en begrepen te hebben.
Ik heb de mogelijkheid gehad om vragen stellen. Mijn vragen zijn goed genoeg beantwoord.
Ik had genoeg tijd om te beslissen of ik meedoe.Ik ben 18 jaar of ouder en wilsbekwaam.
Ik geef toestemming voor het anoniem verzamelen, bewaren en gebruiken van mijn gegevens in dit onderzoek.
Ik weet dat meedoen vrijwillig is en dat ik op elk moment tijdens het onderzoek kan stoppen.

- Ja, de bovenstaande informatie is op mij van toepassing en ik wil meedoen met het onderzoek
- Nee, ik wil niet meedoen met het onderzoek

D Debriefing

Dank u wel voor het invullen van deze vragenlijst.

In dit onderzoek werd er met behulp van vragen over ‘visual literacy’ (visuele geletterdheid) gekeken worden naar hoe u procesmodellen leest. Hopelijk kunnen wij met behulp van deze gegevens in de toekomst de leesbaarheid van procesmodellen verbeteren om zo het begrip te vergroten. Hierbij waren vier condities, drie condities met een nudge (visueel hulpmiddel) en één zonder. U werd op gerandomiseerde basis ingedeeld.

Mocht u nog vragen of opmerkingen hebben, kunt u die stellen via de volgende e-mailadressen:
klachtenfunctionaris-fetcsocwet@uu.nl (klachtenfuctionaris)
i.mulder7@students.uu.nl (onderzoeker)
l.m.j.swinkels@uu.nl (begeleider)

Bent u student aan de Universiteit Utrecht en deed u mee aan dit onderzoek voor PPU, dan kunt u op de onderstaande link klikken om uw studentnummer in te vullen.
Klik deze link.

Wilt u kans maken op de cadeaukaart kunt u op de volgende link klikken om uw e-mailadres achter te laten, zodat er contact met u kan worden opgenomen.

Klik deze link.

E Introduction to the Questionnaires

Efficiency of Visual Literacy Scale (EVLS)

Het eerste deel van de vragenlijst zal gaan over visual literacy (visuele geletterdheid). De bedoeling is dat u de uitspraak leest en kiest hoe gemakkelijk de uitspraken voor u zijn (toe te passen). Hierbij zijn geen goede of foute antwoorden, het gaat om uw eigen invulling.

Understanding of Process Models Scale (UPMS)

U heeft het eerste deel over visualisatie afgerond. Er zullen nu vragen volgen over een aantal procesmodellen. Er worden procesmodellen weergegeven waarop één of twee vragen volgen, deze vragen gaan over het bovenstaande procesmodel. De bedoeling is dat u het antwoord kiest waarvan u denkt dat het het juiste antwoord is.

Demographic questions

U heeft het eerste en tweede deel afgerond en nu volgt het derde en laatste deel. Dit betreft een aantal vragen over uw demografische gegevens.

F Efficiency of Visual Literacy Scale

Efficiency of Visual Literacy Scale (EVLS)

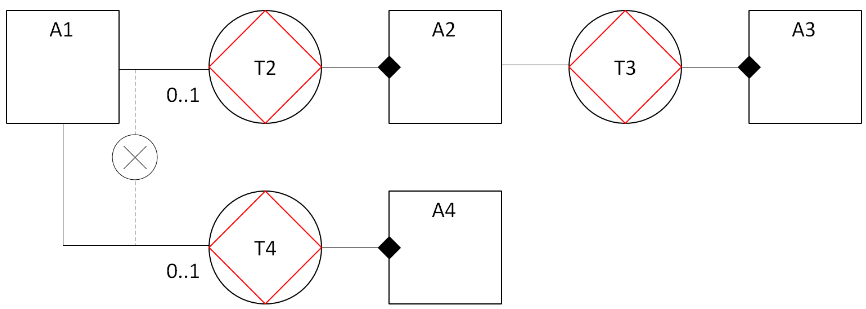
Artikelnummers		Ik kan het absoluut niet doen	Ik kan het niet doen	Ik kan het een beetje doen	Ik kan het doen	Ik kan het heel gemakkelijk doen
Belang hechten aan visualiteit door gebruik te maken van spellingscontrole						
1 (m13)	Ik gebruik onderwerptitels in mijn artikelen					
2 (m14)	Ik gebruik opsommingstekens in mijn artikelen					
3 (m15)	Ik gebruik afbeeldingen in mijn artikelen					
4 (m16)	Ik gebruik tabellen in mijn artikelen					
5 (m17)	Ik gebruik afbeeldingen en foto's in mijn artikelen					
6 (m18)	Ik gebruik tekeningen in mijn artikelen					
7 (m19)	Ik gebruik de juiste lettertypen in mijn artikelen					
Inzicht in het beschrijven van gedrukt beeldmateriaal						
8 (m26)	Ik identificeer patronen in grafieken					
9 (m27)	Ik identificeer complexe vormen in afbeeldingen					
10 (m28)	Ik begrijp speciale tekens op kaarten					
11 (m29)	Ik vind mijn weg met behulp van een kaart					
Visuele interpretatie						
12 (m30)	Ik kan vormen begrijpen met behulp van afbeeldingen					
13 (m31)	Ik rangschik mijn teksten op een leesbare manier					
14 (m32)	Ik zorg ervoor dat de artikelen die ik schrijf er goed uit zien					
15 (m33)	Ik geef een eigen uitleg over foto's en tekeningen					
16 (m34)	Ik creëer betekenis voor foto's					
Visueel onderscheid maken tussen de berichten die ik in het dagelijkse leven tegenkomt						
17 (m23)	Ik begrijp de betekenis van verkeersborden					
18 (m25)	Ik begrijp de symbolen op de afstandsbediening					

19 (m35)	Ik begrijp de pictogrammen (familie, geweld, angst, seksualiteit, enz) op TV					
20 (m36)	Ik maak een onderscheid tussen de logo's op het internet					
21 (m37)	Ik maak een onderscheid tussen de reclames op het internet					
Mogelijkheid om afbeeldingen te produceren met behulp van tools						
22 (m1)	Ik gebruik een scanner voor foto's en documenten					
23 (m2)	Ik gebruik een digitale foto camera					
24 (m3)	Ik bewerk en orden mijn foto's op mijn computer (knippen, kleuren, enz.)					
25 (m4)	Ik gebruik een digital video camera					
26 (m5)	Ik maak een videoclips met een videobewerkingsprogramma					
Begrijpen van de berichten in de afbeeldingen						
27 (m9)	Ik bekijk advertenties					
28 (m10)	Ik begrijp de betekenis op van foto's en tekeningen					
29 (m11)	Ik ken de beperkingen van mijn uitleg over foto's en tekeningen					

G Understanding of Process Models Scale

No Nudge Conditie

VergelijkingsVolgorde



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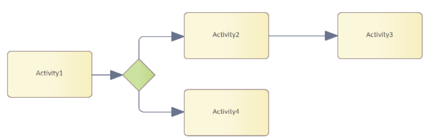

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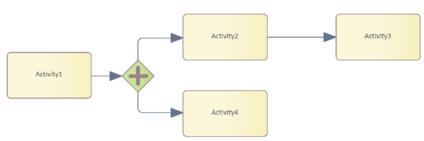

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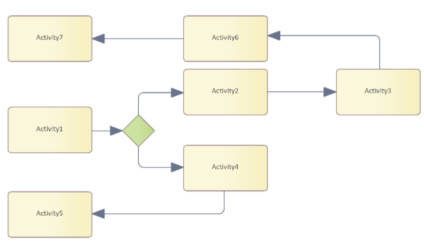

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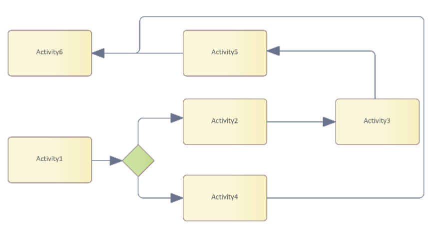
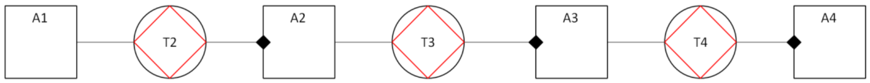


1

VergelijkingsBeste



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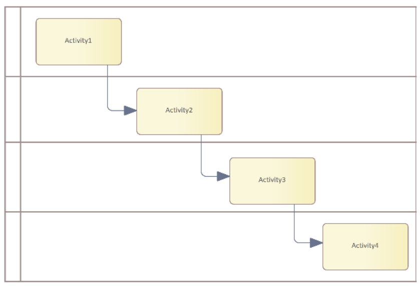

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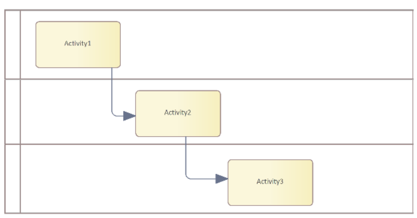

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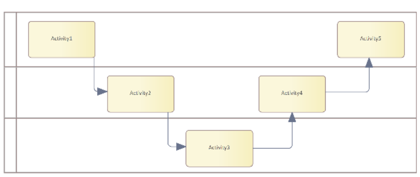

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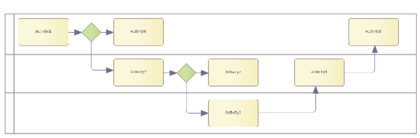
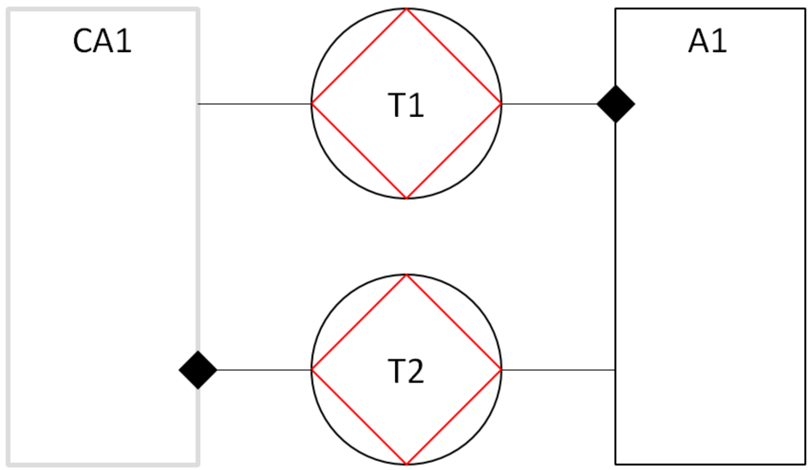


1

Simpel



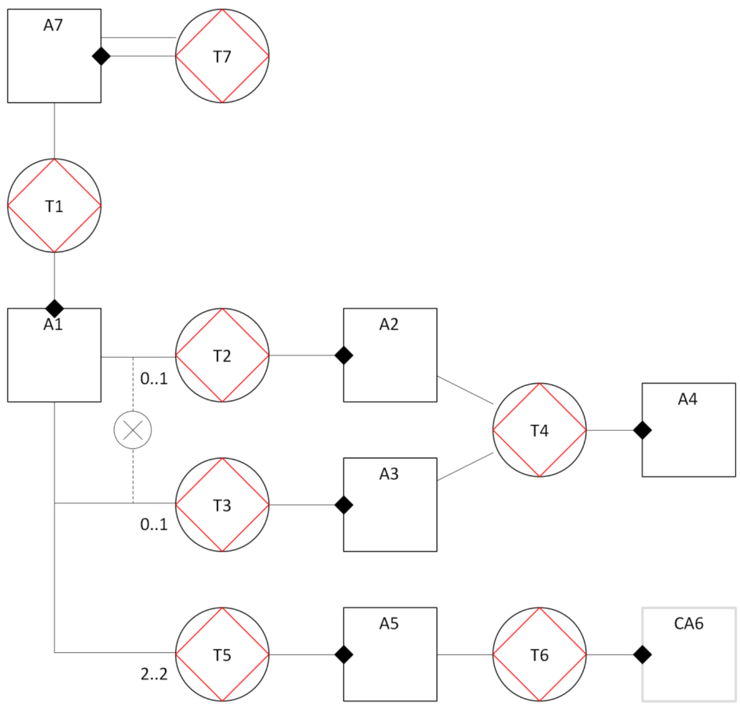
Wat wordt hier weergegeven?

- Onderhandeling
- Uitwisseling van producten
- Repeterende handeling
- Uitwisseling van informatie

Wat is de goede volgorde van raken van de elementen bij het uitvoeren van het proces?

- CA1 > T1 > A1 > T2
- CA1 > T2 > A1 > T1
- A1 > T2 > CA1 > T1
- T1 > A1 > T2 > CA1

Complex



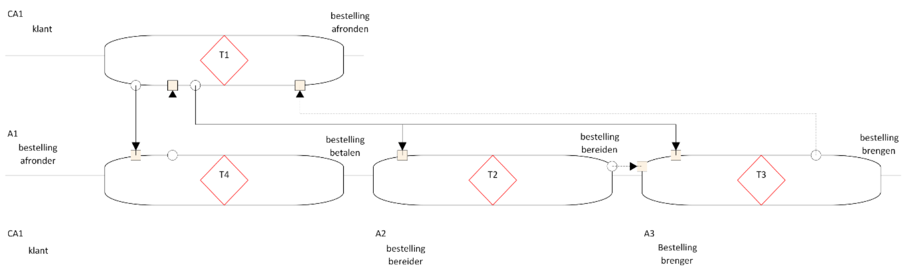
Waar begint het procesmodel?

- T7
- T1
- A7
- CA6

Voor elke T1 die wordt uitgevoerd hoe vaak worden T4 en T6 uitgevoerd?

- 1x T4 en 1x T6
- 2x T4 en 2x T6
- 1x T4 en 2x T6
- misschien T4 en 2x T6

Simpel met Tekst



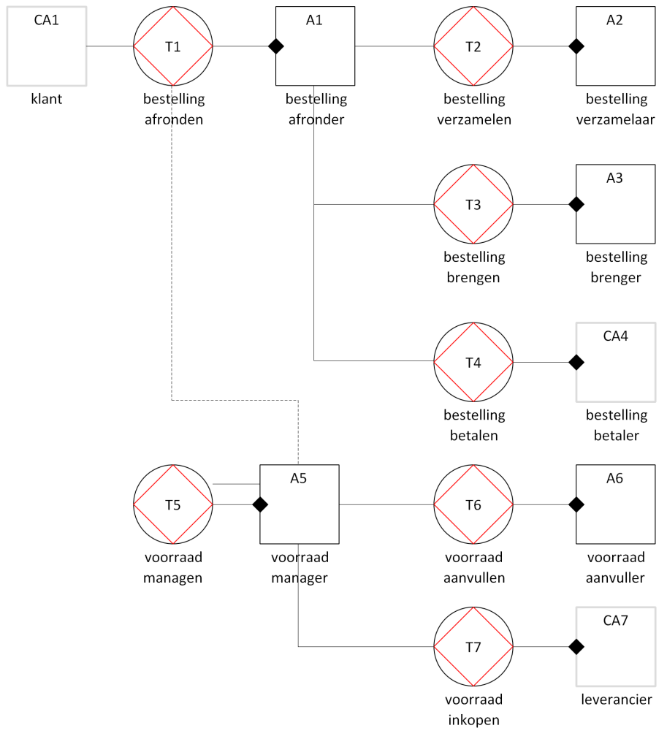
In welke volgorde verloopt de communicatie?

- afronden > betalen > bereiden > brengen
- afronden > betalen > brengen > bereiden
- afronden > bereiden > betalen > brengen
- betalen > afronden > bereiden > brengen

Wat is de procesvolgorde voor het gewenste product?

- brengen > bereiden > afronden
- afronden > bereiden > brengen
- afronden > bereiden > brengen > afronden
- bereiden > brengen > afronden

Complex met Tekst



Wat wordt hier weergegeven?

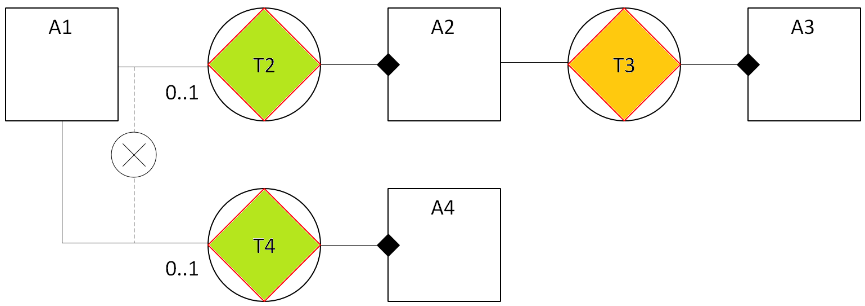
- Verkoop
- Voorraadbeheer
- Inkoop
- Alle bovenstaande opties

Op hoeveel manieren kunnen processen volgens dit procesmodel starten?

- 1 manier
- 2 manieren
- 3 manieren
- 4 manieren

Colour Nudge Conditie

VergelijkingsVolgorde



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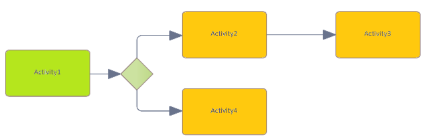

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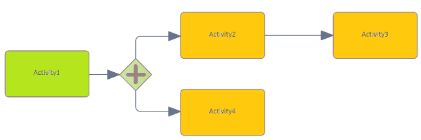

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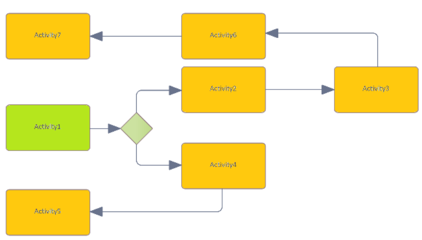

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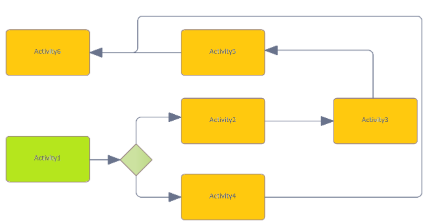

1

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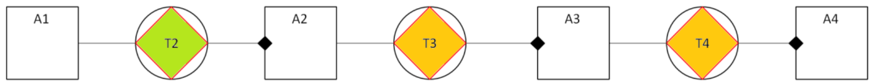

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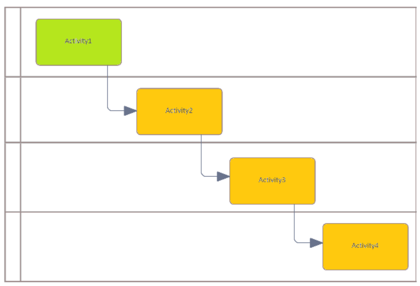

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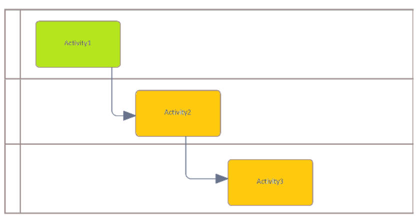

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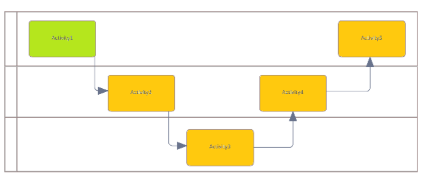

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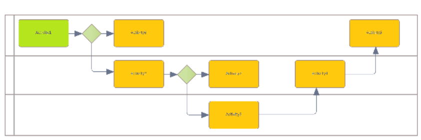
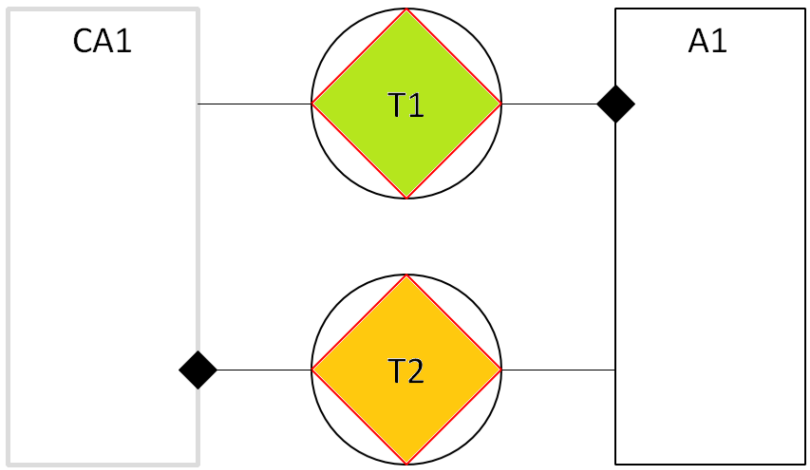


1

Simpel



Wat wordt hier weergegeven?

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Wat is de goede volgorde van het procesmodel uitvoeren?

- CA1 > T1 > A1 > T2
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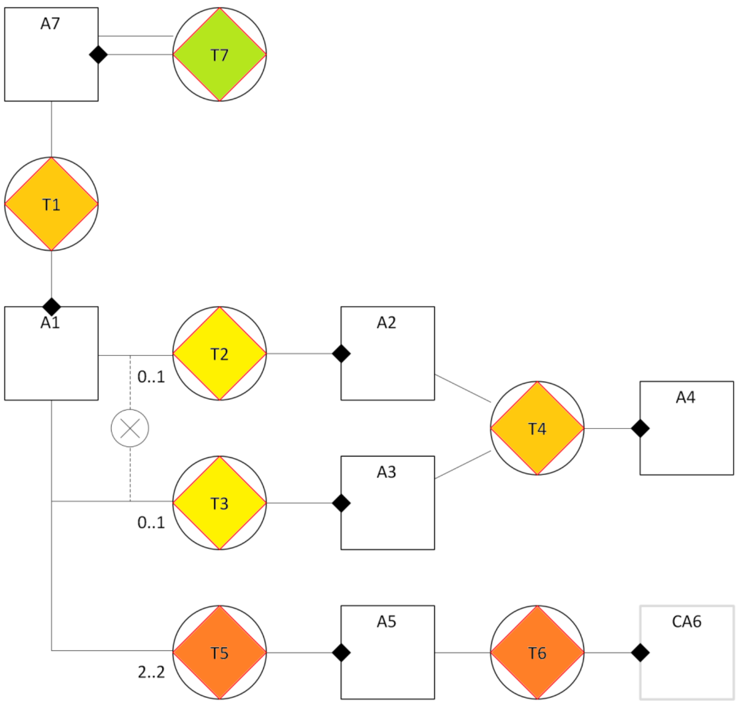
Complex



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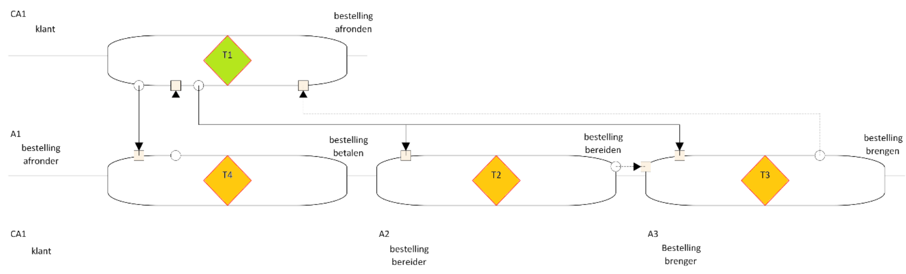


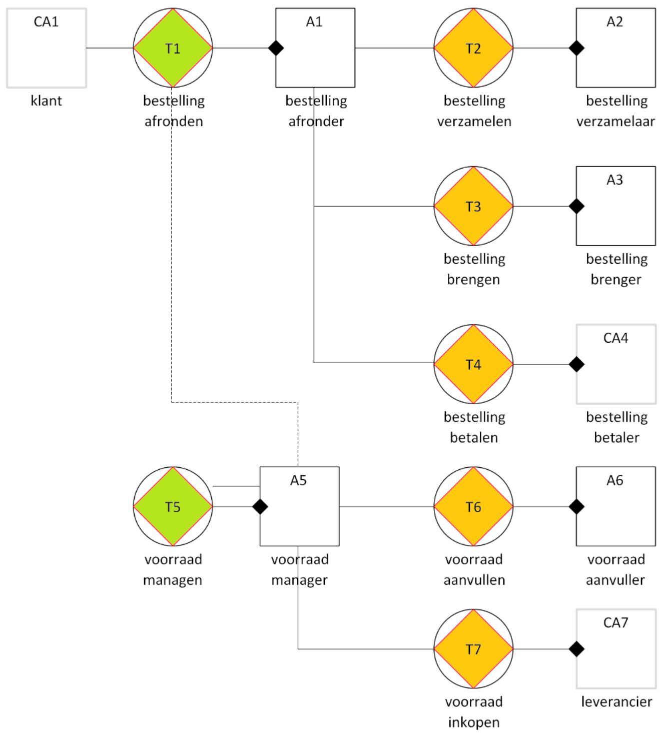
In welke volgorde verloop de communicatie?

- afronden > betalen > bereiden > brengen
- afronden > bereiden > brengen > betalen
- afronden > bereiden > betalen > brengen
- betalen > afronden > bereiden > brengen

Wat is de product volgorde?

- brenger > bereider > klant
- klant > bereider > brenger
- klant > bereider > brenger > klant
- bereider > brenger > klant

Complex met Tekst



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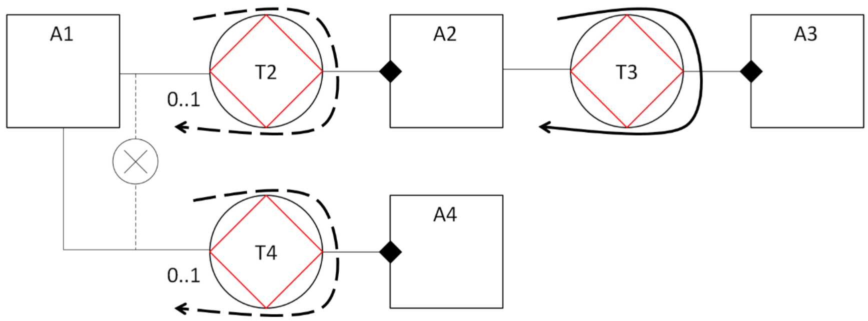
Arrow Nudge Conditie

VergelijkingsVolgorde



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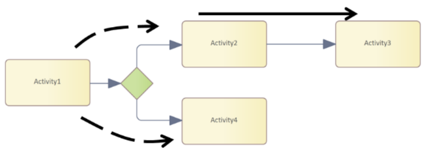

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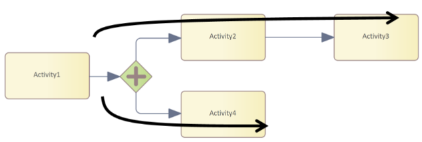

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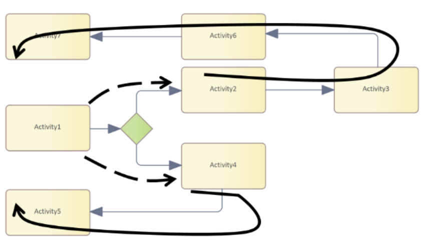

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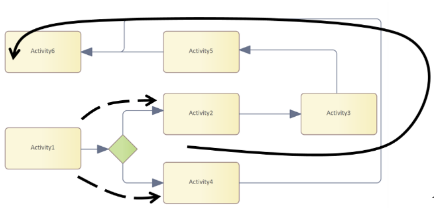

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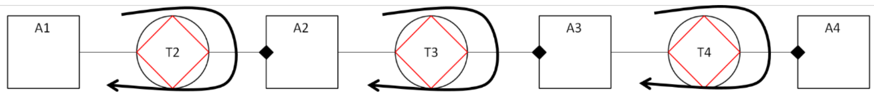

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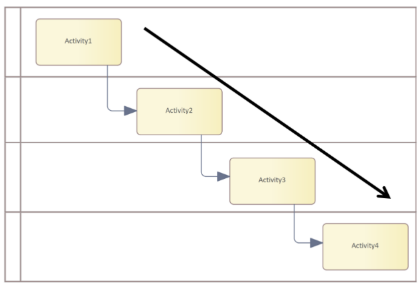

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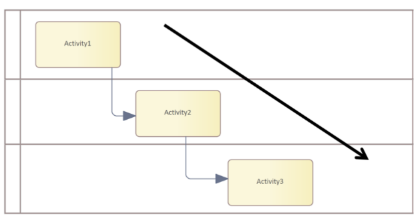

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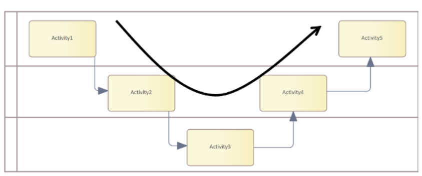

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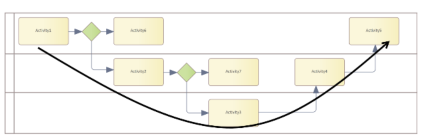
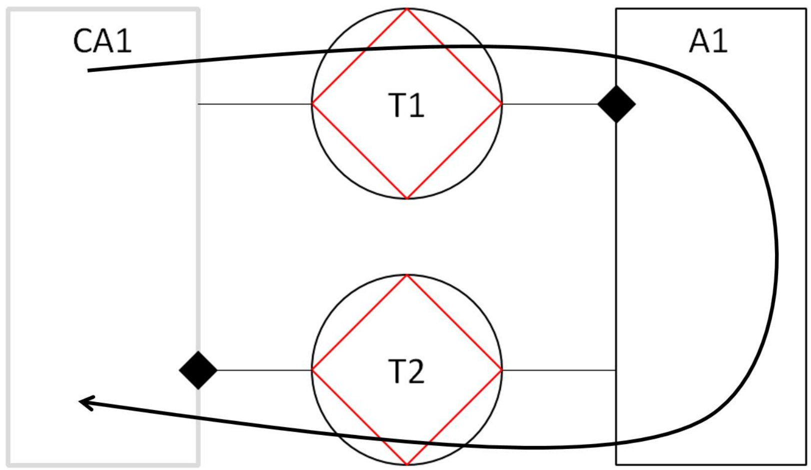


1

Simpel



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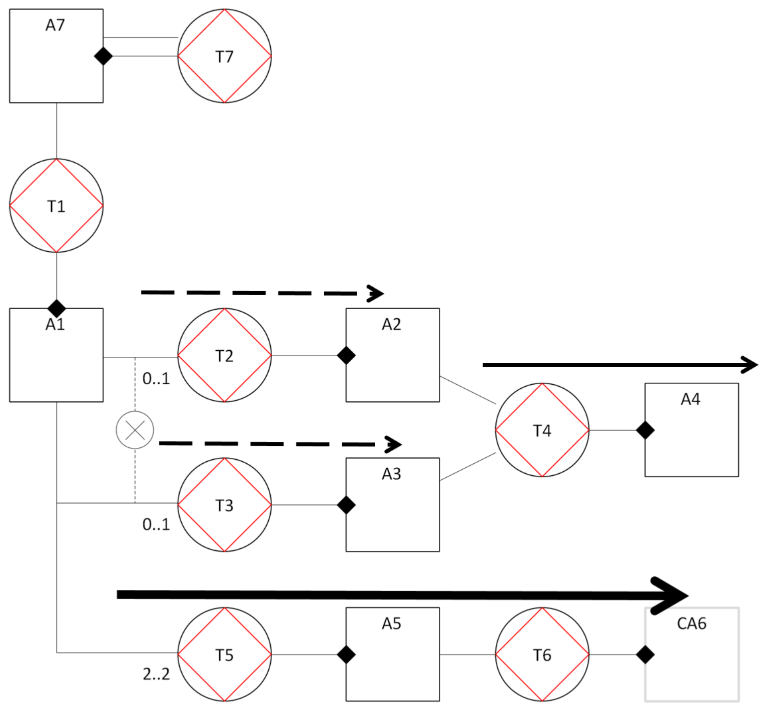

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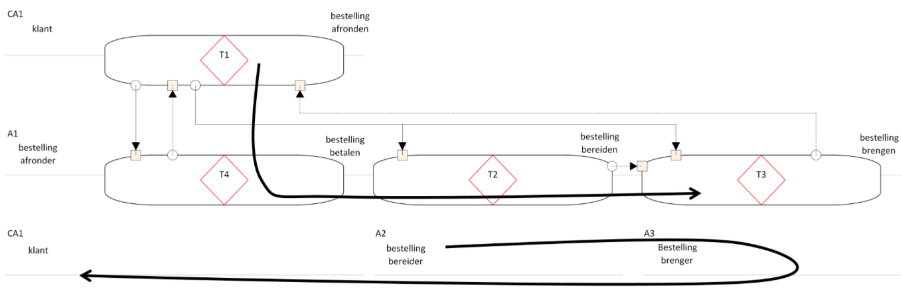

In welke volgorde verloop de communicatie?

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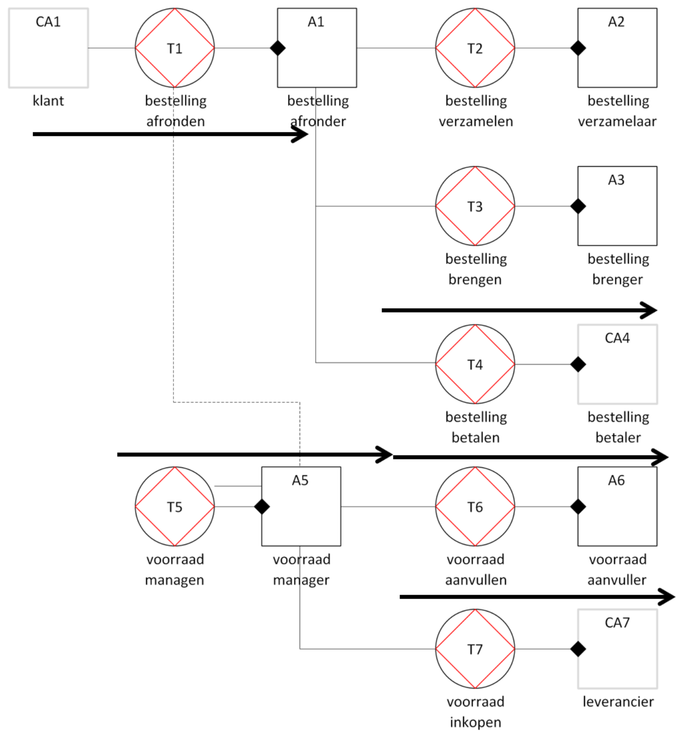
- afronden > bereiden > brengen > betalen
- afronden > bereiden > betalen > brengen
- betalen > afronden > bereiden > brengen

Wat is de product volgorde?

- brenger > bereider > klant
- klant > bereider > brenger
- klant > bereider > brenger > klant
- bereider > brenger > klant

Complex met Tekst



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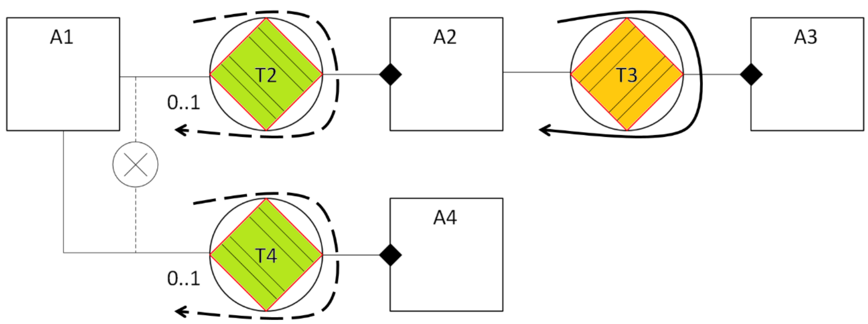
Arrow and Colour Nudge Conditie

VergelijkingsVolgorde



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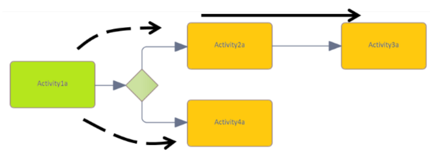

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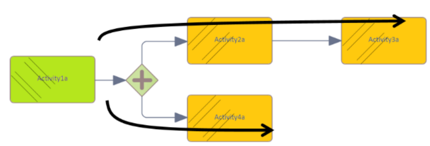

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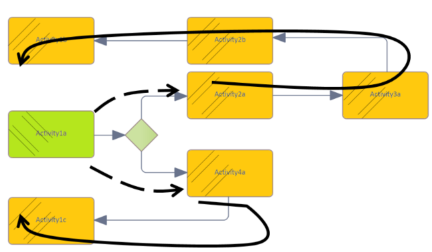

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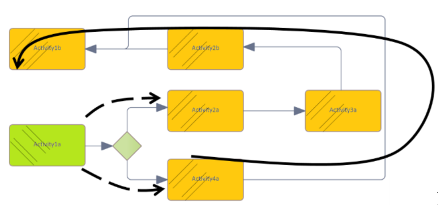
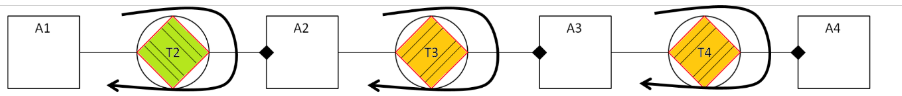


1

VergelijkingsBeste



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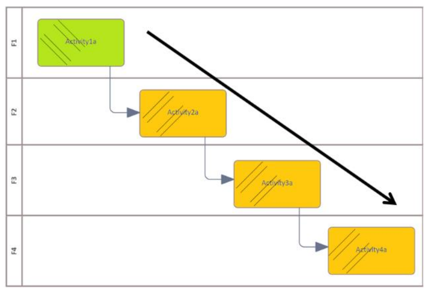
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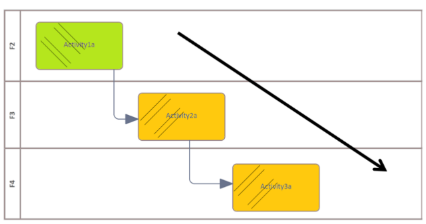
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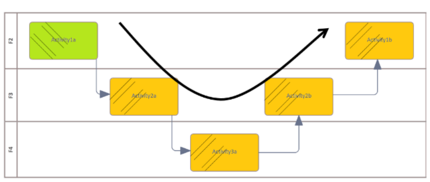
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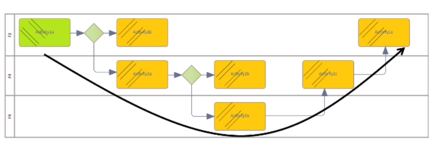
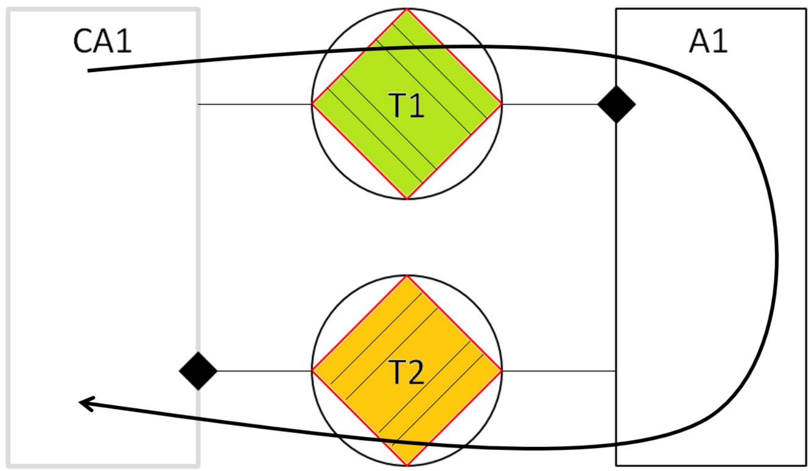

1

Simpel



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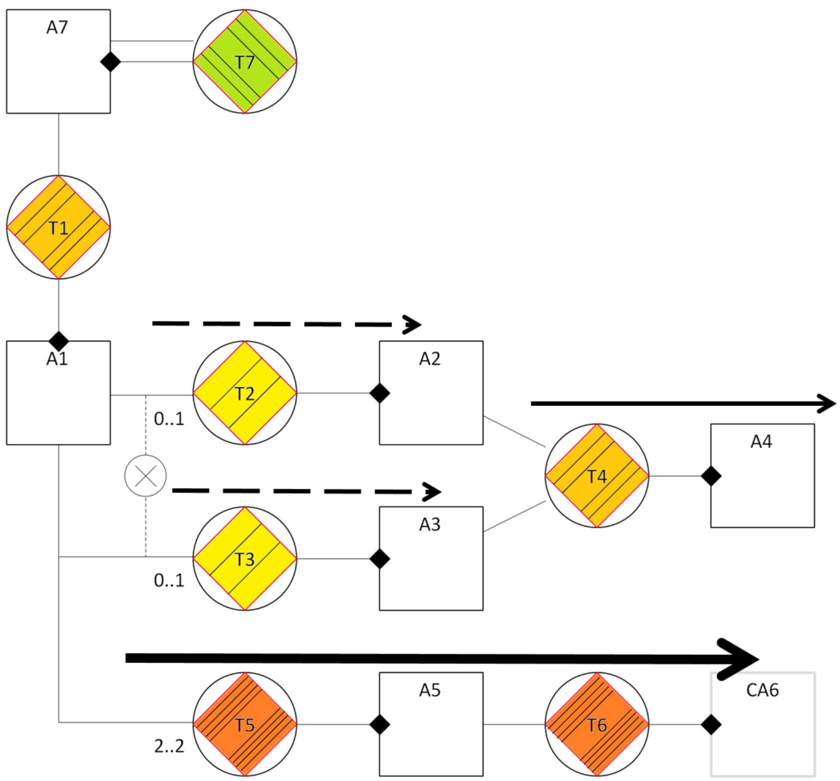

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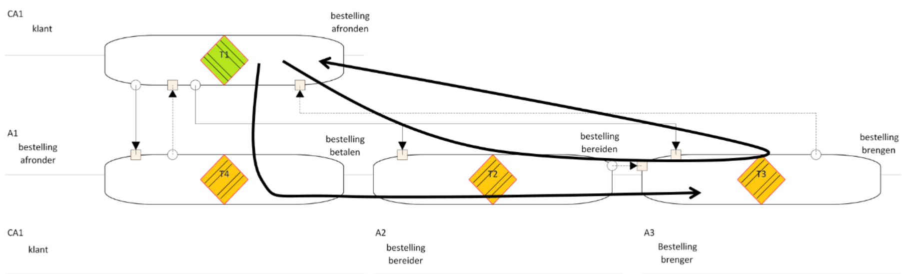
Simpel met Tekst



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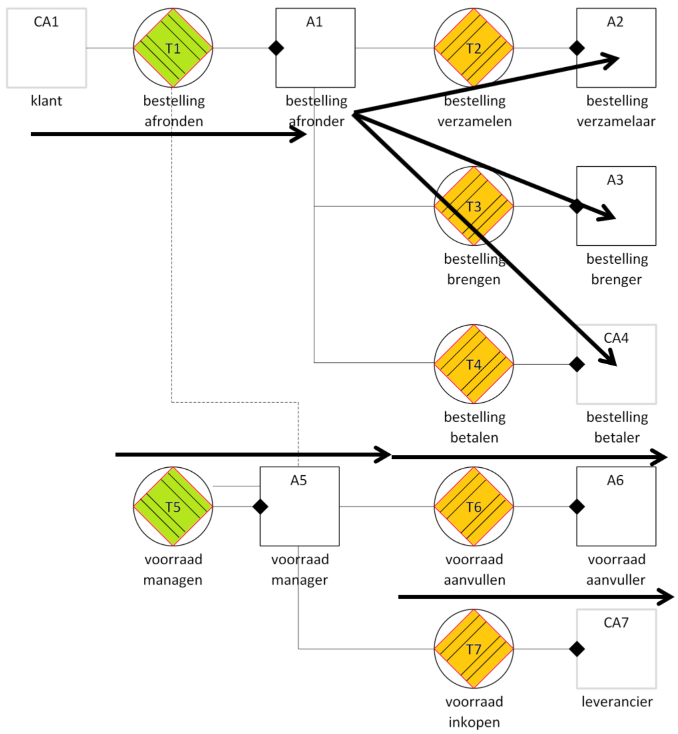

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- Inkoop
- Alle bovenstaande opties

Op hoeveel manieren kan dit procesmodel starten?

- 1 manier
- 2 manieren
- 3 manieren
- 4 manieren

H Demographic Questions

Wat is uw geslacht?

- Man
- Vrouw
- Wil ik voor mijzelf houden
- Anders, namelijk... [vrij in te vullen]

Hoe oud bent u?

[vrij in te vullen]

In welk continent bent u opgegroeid?

- Afrika
- Antarctica
- Australië
- Azië
- Europa
- Noord-Amerika
- Zuid-Amerika

Wat is uw huidige opleidingsniveau of hoogst genoten opleidingsniveau?

- Basisschool
- LBO
- VMBO/MAVO

- HAVO
- VWO
- MBO
- HBO
- WO
- Anders, namelijk... [vrij in te vullen]

Op welk niveau bent u werkzaam?

- C-level
- Directie
- Staf
- Management
- Team
- Medewerker
- Anders, namelijk... [vrij in te vullen]

In welke branche bent u werkzaam?

- Financieel
- Serviceverlening
- Energie
- Industrie
- Bouw
- Detailhandel
- ICT

- Entertainment
- Logistiek
- Onderwijs/Opleiding
- Overheid/Non-profit
- Anders, namelijk... [vrij in te vullen]

Bent u kleurenblind?

- Ja
- Nee

I Syntax

```

* Encoding: UTF-8.


*making case numbers

COMPUTE CaseNumber=$CASENUM.
EXECUTE.


*descriptives of age

DESCRIPTIVES VARIABLES=leeftijd
  /STATISTICS=MEAN STDDEV MIN MAX.


*frequencies geslacht

FREQUENCIES VARIABLES=geslacht
  /ORDER=ANALYSIS.


*recoding the understanding of process models

RECODE nn_s2 nn_c1 nn_st1 cn_s2 cn_c1 cn_st1 an_s2 an_c1 an_st1
    acn_s2 acn_c1 acn_st1 nn_vv_3 cn_vv_3 an_vv_3 acn_vv_3 (1=1)
    (2=0)
```

```
 (3=0) (4=0) INTO recode_nn_s2 recode_nn_c1 recode_nn_st1 recode_cn_s2 recode_cn_c1 recode_cn_st1
 recode_an_s2 recode_an_c1 recode_an_st1 recode_acn_s2 recode_acn_c1 recode_acn_st1 recode_nn_vv_3 recode_cn_vv_3 recode_an_vv_3 recode_acn_vv_3.
EXECUTE.

RECODE nn_s1 nn_ct2 cn_s1 cn_ct2 an_s1 an_ct2 acn_s1 acn_ct2 nn_vv_4 cn_vv_4 an_vv_4 acn_vv_4 (1=0) (2=1) (3=0) (4=0) INTO
 recode_nn_s1 recode_nn_ct2 recode_cn_s1 recode_cn_ct2 recode_an_s1 recode_an_ct2 recode_acn_s1
 recode_acn_ct2 recode_nn_vv_4 recode_cn_vv_4 recode_an_vv_4 recode_acn_vv_4.
EXECUTE.

RECODE nn_c2 cn_c2 an_c2 acn_c2 nn_vv_2 cn_vv_2 an_vv_2 acn_vv_2 (1=0) (2=0) (3=1) (4=0) INTO recode_nn_c2 recode_cn_c2 recode_an_c2
 recode_acn_c2 recode_nn_vv_2 recode_cn_vv_2 recode_an_vv_2 recode_acn_vv_2.
EXECUTE.

RECODE nn_vb nn_st2 nn_ct1 cn_vb cn_st2 cn_ct1 an_vb an_st2 an_ct1 acn_vb acn_st2 acn_ct1 nn_vv_1 cn_vv_1 an_vv_1 acn_vv_1 (1=0)
 (2=0) (3=0) (4=1) INTO recode_nn_vb recode_nn_st2 recode_nn_ct1 recode_cn_vb recode_cn_st2
 recode_cn_ct1 recode_an_vb recode_an_st2 recode_an_ct1
```

```
    recode_acn_vb recode_acn_st2 recode_acn_ct1 recode_nn_vv_1
    recode_cn_vv_1
     recode_an_vv_1 recode_acn_vv_1.
EXECUTE.


*calculate sumscore understanding of process models

COMPUTE SUM_nn=recode_nn_s2+recode_nn_c1+recode_nn_st1+
    recode_nn_vv_3+recode_nn_s1+recode_nn_ct2+
     recode_nn_vv_4+recode_nn_c2+recode_nn_vv_2+recode_nn_vb+
    recode_nn_st2+recode_nn_ct1+recode_nn_vv_1.
EXECUTE.

COMPUTE SUM_cn=recode_cn_s2+recode_cn_c1+recode_cn_st1+
    recode_cn_vv_3+recode_cn_s1+recode_cn_ct2+
     recode_cn_vv_4+recode_cn_c2+recode_cn_vv_2+recode_cn_vb+
    recode_cn_st2+recode_cn_ct1+recode_cn_vv_1.
EXECUTE.

COMPUTE SUM_an=recode_an_s2+recode_an_c1+recode_an_st1+
    recode_an_vv_3+recode_an_s1+recode_an_ct2+
     recode_an_vv_4+recode_an_c2+recode_an_vv_2+recode_an_vb+
    recode_an_st2+recode_an_ct1+recode_an_vv_1.
EXECUTE.

COMPUTE SUM_acn=recode_acn_s2+recode_acn_c1+recode_acn_st1+
    recode_acn_vv_3+recode_acn_s1+
```

```
    recode_acn_ct2+recode_acn_vv_4+recode_acn_c2+recode_acn_vv_2
   +recode_acn_vb+recode_acn_st2+
    recode_acn_ct1+recode_acn_vv_1.
EXECUTE.


*number of cases in each condition

DESCRIPTIVES VARIABLES=SUM_nn SUM_cn SUM_an SUM_acn
  /STATISTICS=MEAN STDDEV MIN MAX.


*making one sum scores of the different conditions

RECODE SUM_nn SUM_cn SUM_an SUM_acn (1 thru 13=Copy) (ELSE=0)
   INTO SUM_nn_temp SUM_cn_temp
    SUM_an_temp SUM_acn_temp.
EXECUTE.


*making one score for the different cases

IF  (SUM_nn > 0) nn=0.
EXECUTE.

RECODE nn (0=0) (ELSE=0).
EXECUTE.

```

```
IF  (SUM_cn > 0) cn=1.
EXECUTE.

RECODE cn (1=1) (ELSE=0).
EXECUTE.

IF  (SUM_an > 0) an=2.
EXECUTE.

RECODE an (2=2) (ELSE=0).
EXECUTE.

IF  (SUM_acn > 0) acn=3.
EXECUTE.

RECODE acn (3=3) (ELSE=0).
EXECUTE.

COMPUTE nudgeconditions=nn+cn+an+acn.
EXECUTE.


*sum score of the UPM

COMPUTE Score_UPM=SUM_nn_temp + SUM_cn_temp + SUM_an_temp +
    SUM_acn_temp.
EXECUTE.

```

```

*sum score of the evls

COMPUTE SUM_EVLS=A1__m13_+A2__m14_+A3__m15_+A4__m16_+A5__m17_+
    A6__m18_+A7__m19_+A8__m26_+A9__m27_+
     A10__m28_+A11__m29_+A12__m30_+A13__m31_+A14__m32_+A15__m33_+
    A16__m34_+A17__m23_+A18__m25_+A19__m35_+
     A20__m36_+A21__m27_+A22__m1_+A23__m2_+A24__m3_+A25__m5_+
    A26__m5_+A27__m9_+A28__m10_+A29__m11_.
EXECUTE.


*recoding conditions for anova

IF  (SUM_cn > 0 OR SUM_acn > 0) colournudge=1.
EXECUTE.

IF  (SUM_an > 0 OR SUM_acn > 0) arrownudge=1.
EXECUTE.

RECODE colournudge arrownudge (1=1) (ELSE=0).
EXECUTE.


*UPM and EVLS linearity check

GRAPH
  /SCATTERPLOT(BIVAR)=SUM_EVLS WITH Score_UPM
```

```
  /MISSING=LISTWISE.


*regression with interaction with EVLS

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Score_UPM
  /METHOD=ENTER SUM_EVLS cn_dummy an_dummy acn_dummy
    EVLSxcndummy EVLSxandummy EVLSxacndummy
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HISTOGRAM(ZRESID)
  /SAVE MAHAL COOK ZRESID.


*making standerdized values of EVLS

DESCRIPTIVES VARIABLES=SUM_EVLS
  /SAVE
  /STATISTICS=MEAN STDDEV MIN MAX.


*gestandaardiseerde UPM om offcut scores for outliers te zien

DESCRIPTIVES VARIABLES=Score_UPM
```

```
  /SAVE
  /STATISTICS=MEAN STDDEV MIN MAX.


*ZEVLS x dummy

COMPUTE ZEVLSxcndummy=ZSUM_EVLS * cn_dummy.
EXECUTE.

COMPUTE ZEVLSxandummy=ZSUM_EVLS * an_dummy.
EXECUTE.

COMPUTE ZEVLSxacndummy=ZSUM_EVLS * acn_dummy.
EXECUTE.


*regression with interaction with ZEVLS, with standardised
   residuals, mahalanobis distance and cook's distance to check
   of absence of outliers.
    *collinearity diagnostics to check for absence of
   multicollinearity
    *plots to check for homoscedasticity and normally
   distributed residuals

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL
  /CRITERIA=PIN(.05) POUT(.10)
```

```
  /NOORIGIN
  /DEPENDENT Score_UPM
  /METHOD=ENTER ZSUM_EVLS cn_dummy an_dummy acn_dummy
    ZEVLSxcndummy ZEVLSxandummy ZEVLSxacndummy
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HISTOGRAM(ZRESID)
  /SAVE MAHAL COOK ZRESID.



*cronbachs alpha EVLS all cases incl

RELIABILITY
  /VARIABLES=A1__m13_ A2__m14_ A3__m15_ A4__m16_ A5__m17_
    A6__m18_ A7__m19_ A8__m26_ A9__m27_
     A10__m28_ A11__m29_ A12__m30_ A13__m31_ A14__m32_ A15__m33_
    A16__m34_ A17__m23_ A18__m25_ A19__m35_
     A20__m36_ A21__m27_ A22__m1_ A23__m2_ A24__m3_ A25__m5_
    A26__m5_ A27__m9_ A28__m10_ A29__m11_
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.


*cronbachs alpha EVLS deleted case 12,34,40

RELIABILITY
  /VARIABLES=A1__m13_ A2__m14_ A3__m15_ A4__m16_ A5__m17_
```

```
    A6__m18_ A7__m19_ A8__m26_ A9__m27_
     A10__m28_ A11__m29_ A12__m30_ A13__m31_ A14__m32_ A15__m33_
    A16__m34_ A17__m23_ A18__m25_ A19__m35_
     A20__m36_ A21__m27_ A22__m1_ A23__m2_ A24__m3_ A25__m5_
    A26__m5_ A27__m9_ A28__m10_ A29__m11_
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.




*anova all cases

UNIANOVA Score_UPM BY colournudge arrownudge WITH ZSUM_EVLS
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(arrownudge colournudge colournudge*arrownudge)
    TYPE=LINE ERRORBAR=NO
     MEANREFERENCE=NO YAXIS=AUTO
  /EMMEANS=TABLES(arrownudge*colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(arrownudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(OVERALL) WITH(ZSUM_EVLS=MEAN)
  /PRINT ETASQ DESCRIPTIVE PARAMETER
  /CRITERIA=ALPHA(.05)
  /DESIGN=colournudge arrownudge ZSUM_EVLS ZSUM_EVLS*arrownudge
    ZSUM_EVLS*colournudge
```

```
    arrownudge*colournudge ZSUM_EVLS*arrownudge*colournudge.

GRAPH
  /SCATTERPLOT(BIVAR)=ZSUM_EVLS WITH Score_UPM BY arrownudge
  /MISSING=LISTWISE.



*anova deleted case 34,40

UNIANOVA Score_UPM BY colournudge arrownudge WITH ZSUM_EVLS
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(arrownudge colournudge colournudge*arrownudge)
   TYPE=LINE ERRORBAR=NO
    MEANREFERENCE=NO YAXIS=AUTO
  /EMMEANS=TABLES(arrownudge*colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(arrownudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(OVERALL) WITH(ZSUM_EVLS=MEAN)
  /PRINT ETASQ DESCRIPTIVE PARAMETER
  /CRITERIA=ALPHA(.05)
  /DESIGN=colournudge arrownudge ZSUM_EVLS ZSUM_EVLS*arrownudge
   ZSUM_EVLS*colournudge
    arrownudge*colournudge ZSUM_EVLS*arrownudge*colournudge.

GRAPH
  /SCATTERPLOT(BIVAR)=ZSUM_EVLS WITH Score_UPM BY arrownudge
```

```
  /MISSING=LISTWISE.



*anova deleted case 12

UNIANOVA Score_UPM BY colournudge arrownudge WITH ZSUM_EVLS
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(arrownudge colournudge colournudge*arrownudge)
    TYPE=LINE ERRORBAR=NO
     MEANREFERENCE=NO YAXIS=AUTO
  /EMMEANS=TABLES(arrownudge*colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(arrownudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(OVERALL) WITH(ZSUM_EVLS=MEAN)
  /PRINT ETASQ DESCRIPTIVE PARAMETER
  /CRITERIA=ALPHA(.05)
  /DESIGN=colournudge arrownudge ZSUM_EVLS ZSUM_EVLS*arrownudge
    ZSUM_EVLS*colournudge
     arrownudge*colournudge ZSUM_EVLS*arrownudge*colournudge.

GRAPH
  /SCATTERPLOT(BIVAR)=ZSUM_EVLS WITH Score_UPM BY arrownudge
  /MISSING=LISTWISE.


*anova deleted case 12,34,40
```

```
UNIANOVA Score_UPM BY colournudge arrownudge WITH ZSUM_EVLS
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(arrownudge colournudge colournudge*arrownudge)
    TYPE=LINE ERRORBAR=NO
     MEANREFERENCE=NO YAXIS=AUTO
  /EMMEANS=TABLES(arrownudge*colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(colournudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(arrownudge) WITH(ZSUM_EVLS=MEAN)
  /EMMEANS=TABLES(OVERALL) WITH(ZSUM_EVLS=MEAN)
  /PRINT ETASQ DESCRIPTIVE PARAMETER
  /CRITERIA=ALPHA(.05)
  /DESIGN=colournudge arrownudge ZSUM_EVLS ZSUM_EVLS*arrownudge
    ZSUM_EVLS*colournudge
     arrownudge*colournudge ZSUM_EVLS*arrownudge*colournudge.

GRAPH
  /SCATTERPLOT(BIVAR)=ZSUM_EVLS WITH Score_UPM BY arrownudge
  /MISSING=LISTWISE.



*charts om te kijken welk effect meer verklaarde variantie heeft
    , all cases

* Chart Builder.
GGRAPH
```

```
  /GRAPHDATASET NAME="graphdataset" VARIABLES=ZSUM_EVLS
    Score_UPM nudgeconditions MISSING=LISTWISE
     REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: ZSUM_EVLS=col(source(s), name("ZSUM_EVLS"))
  DATA: Score_UPM=col(source(s), name("Score_UPM"))
  DATA: nudgeconditions=col(source(s), name("nudgeconditions"),
    unit.category())
  GUIDE: axis(dim(1), label("Zscore(SUM_EVLS)"))
  GUIDE: axis(dim(2), label("Score_UPM"))
  GUIDE: legend(aesthetic(aesthetic.color.interior), label("
    nudgeconditions"))
  GUIDE: text.title(label("Multiple Line of Score_UPM by Zscore(
    SUM_EVLS) by nudgeconditions"))
  ELEMENT: line(position(ZSUM_EVLS*Score_UPM), color.interior(
    nudgeconditions), missing.wings())
END GPL.


* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=ZSUM_EVLS
    Score_UPM nudgeconditions MISSING=LISTWISE
     REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE
  /FITLINE TOTAL=NO SUBGROUP=NO.
```

```
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: ZSUM_EVLS=col(source(s), name("ZSUM_EVLS"))
  DATA: Score_UPM=col(source(s), name("Score_UPM"))
  DATA: nudgeconditions=col(source(s), name("nudgeconditions"),
    unit.category())
  GUIDE: axis(dim(1), label("Zscore(SUM_EVLS)"))
  GUIDE: axis(dim(2), label("Score_UPM"))
  GUIDE: legend(aesthetic(aesthetic.color.interior), label("
    nudgeconditions"))
  GUIDE: text.title(label("Scatter Plot of Score_UPM by Zscore(
    SUM_EVLS) by nudgeconditions"))
  ELEMENT: point(position(ZSUM_EVLS*Score_UPM), color.interior(
    nudgeconditions))
END GPL.



*charts om te kijken welk effect meer verklaarde variantie heeft
    , deleted case 34,40

* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=ZSUM_EVLS
    Score_UPM nudgeconditions MISSING=LISTWISE
     REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE.
BEGIN GPL
```

```
  SOURCE: s=userSource(id("graphdataset"))
  DATA: ZSUM_EVLS=col(source(s), name("ZSUM_EVLS"))
  DATA: Score_UPM=col(source(s), name("Score_UPM"))
  DATA: nudgeconditions=col(source(s), name("nudgeconditions"),
    unit.category())
  GUIDE: axis(dim(1), label("Zscore(SUM_EVLS)"))
  GUIDE: axis(dim(2), label("Score_UPM"))
  GUIDE: legend(aesthetic(aesthetic.color.interior), label("
    nudgeconditions"))
  GUIDE: text.title(label("Multiple Line of Score_UPM by Zscore(
    SUM_EVLS) by nudgeconditions"))
  ELEMENT: line(position(ZSUM_EVLS*Score_UPM), color.interior(
    nudgeconditions), missing.wings())
END GPL.


* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=ZSUM_EVLS
    Score_UPM nudgeconditions MISSING=LISTWISE
     REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE
  /FITLINE TOTAL=NO SUBGROUP=NO.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: ZSUM_EVLS=col(source(s), name("ZSUM_EVLS"))
  DATA: Score_UPM=col(source(s), name("Score_UPM"))
  DATA: nudgeconditions=col(source(s), name("nudgeconditions"),
```

```
    unit.category())
  GUIDE: axis(dim(1), label("Zscore(SUM_EVLS)"))
  GUIDE: axis(dim(2), label("Score_UPM"))
  GUIDE: legend(aesthetic(aesthetic.color.interior), label("
    nudgeconditions"))
  GUIDE: text.title(label("Scatter Plot of Score_UPM by Zscore(
    SUM_EVLS) by nudgeconditions"))
  ELEMENT: point(position(ZSUM_EVLS*Score_UPM), color.interior(
    nudgeconditions))
END GPL.



*verdeling opleidingsniveau all cases

FREQUENCIES VARIABLES=opleidingsniveau
  /STATISTICS=STDDEV RANGE MINIMUM MAXIMUM MEAN
  /ORDER=ANALYSIS.




* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=ZSUM_EVLS
    ZScore_UPM arrownudge MISSING=LISTWISE
     REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE
```

```
  /FITLINE TOTAL=NO SUBGROUP=NO.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: ZSUM_EVLS=col(source(s), name("ZSUM_EVLS"))
  DATA: ZScore_UPM=col(source(s), name("ZScore_UPM"))
  DATA: arrownudge=col(source(s), name("arrownudge"), unit.
    category())
  GUIDE: axis(dim(1), label("Zscore(SUM_EVLS)"))
  GUIDE: axis(dim(2), label("Zscore(Score_UPM)"))
  GUIDE: legend(aesthetic(aesthetic.color.interior), label("
    arrownudge"))
  GUIDE: text.title(label("Scatter Plot of Zscore(Score_UPM) by
    Zscore(SUM_EVLS) by arrownudge"))
  ELEMENT: point(position(ZSUM_EVLS*ZScore_UPM), color.interior(
    arrownudge))
END GPL.
```