**1.0 INTRODUCTION**

This paper investigates whether transparent and flexible management control systems with an option to repair improve employee learning. A fundamental role of management control systems (MCSs) is to facilitate learning and decision-making (Atkinson et al., 1997) and the accounting profession relies heavily on individual learning to create new knowledge (Bonner and Walker, 1994; Libby, 1993) and ensure the organisations’ long-term success in a rapidly changing environment (Patil and Tetlock, 2014). For instances, KPMG designed KRisk to assist auditors in assessing and managing client acceptance and continuance risk and to facilitate a high audit quality control (Bell et al., 2002). In the banking industry, loan officers use control systems that formalise the companies risk profile and determine credit risks of a potential borrower (Kumra et al., 2006). Such control systems structure the task of its users and provide information for users so that they gain a better understanding of auditing procedures or credit risk.

The theory on enabling controls argues that controls should be transparent, flexible, and open to repair for users to learn from the system (Adler and Borys, 1996; Ahrens and Chapman, 2004). In a transparent system, the users understand the rationale for the rules and standards in the system. A flexible system allows the users to overrule the standard procedures when appropriate which enable them to experiment and learn from new situations that were not anticipated in the control system. Repairing the system gives the users an opportunity to incorporate what they have learned in the control system.

While the literature finds that these characteristics can contribute to employee learning, they are not always necessary, and flexibility and repair sometimes harm learning. For example, inexperienced users often make mistakes in complex tasks when they deviate from the standards in a flexible management control system resulting in audit errors (Dowling and Leech, 2007) and inaccurate approval of loans (Berg, 2015; Agarwal and Ben-David, 2018).

We hypothesise that users only learn more with flexible controls that are open to repair, when the control system is transparent. Our main argument is that flexibility and repair of control systems add additional cognitive load to a decision making task and take away cognitive resources from MCS users. Internal transparency helps to build a mental model of the control system which decreases the cognitive load of overriding standards and repairing the control systems. With internal transparency, users of the control system are able to use the control system flexibly or repair it if necessary, and as a result learn to perform the task better over time.

We investigate the interaction effects between flexibility or repair and internal transparency on users’ learning using the Sprinkle (2000) multi-period task. In the task, participants decide on production volume without knowing demand of the product. We introduce a management control system that limits the participant’s choices where some of those choices are always suboptimal but others are appropriate with certain demand levels. With internal transparency, we provide users additional explanatory feedback why the choices are not allowed. With flexibility, we give users a right to override the controls. With repair, we give users a right not only to override the control system but also to change the control system so that other choices are no longer allowed in the future or so that some controlled choices are allowed in the future.

Our results indicate that

Our study contributes to the understanding of cognitive process of MCS users, especially that a transparent and flexible or a transparent and repair design of MCS is able to facilitate learning. This finding adds to literature about accounting decision-making and knowledge acquisition in complex tasks (e.g. Griffith et al, 2014). Second, our study contributes to the understanding of Adler and Borys’ (1996) enabling and coercive theoretical framework. To our knowledge, this is the first management accounting study that provides experimental evidence to demonstrate that the effect of flexibility or repair in a system depends on the existence of internal transparency. We connect the case study research of management control system and Cognitive Load Theory from the cognitive sciences so that the literature can borrow the strengths of both perspectives. For instance, our theoretically supported results explain why flexibility and repair do not necessarily improve learning. Third, our findings inform accounting practice, and especially companies who are designing control systems to manage employees and need to give those employees enough freedom to learn on the job. Our findings suggest that this freedom is not sufficient if the employees do not understand the purpose of the control system.

**2.0 THEORY AND HYPOTHESES**

**Management control system and learning**

Management control systems present valuable information to users so that they learn and improve their performance (Chenhall, 2000; Ahrens and Chapman, 2004). For example, a computerised decision aid that provides the rational to tax calculations helps users to acquire tax knowledge and to solve complex tax problems (Rose and Wolfe, 2000). Visualising cost data helps inexperienced users with the interpretation of cost accounting information (Cardinaels, 2008). Performance measures provide feedback about task strategies and allow users to explore and learn better strategies (Sprinkle, 2000). Nevertheless, the literature has also reported that inappropriately designed management control system can limit learning when it hinders users’ cognitive processes (for a review, see Luft and Shields, 2010). For instance, Rose and Wolfe (2000) find that learning decreases when the underlying structure for tax calculations is presented on a different computer screen than the screen with the decision aid.

The accounting literature has built on the formalisation framework of Adler and Borys (1996) to study how management control systems can either enable users to learn and improve performance, or coerce them and restrict their behaviour. This literature has found that an enabling, constructive type of management control system rather than a coercive one is more likely to facilitate its users to acquire knowledge, reflect on their experience, summarise the underlying structure of the system and even improve the system (Ahrens and Chapman, 2004; Wouters & Wilderom, 2008; Wouters and Roijmans, 2011). They argue that designers have to make a management control internally transparent, flexible and give its users the right to repair in order for the system to be enabling. Flexibility refers to users’ discretion over the use of control systems even if a system provides guidelines, internal transparency refers to users’ understanding of the underlying structure of the system and local working processes, and repair refers to the right and capability of users to fix the breakdown of control processes (Adler and Borys, 1996; Ahrens and Chapman, 2004). Therefore, it is generally believed that the enabling design of a system encourages employees to learn and improves their task performance (Free, 2007; Jordan and Messner, 2012).

Even though this literature generally states that flexibility and repair are important characteristics for a system to facilitate learning, we argue that the effect of flexibility or repair is dependent on the internal transparency of the system. In this study, we use the cognitive perspective of Cognitive Load Theory to explain why this is the case. In the remainder of this section, we introduce Cognitive Load Theory and then we discuss the literature on flexibility, internal transparency and repair, then and the hypotheses.

**Intrinsic Cognitive Load and management accounting information**

This study adopts cognitive load theory (CLT) to explain how the design of a control system improves learning. Cognitive load theory is concerned with learning complex tasks and how to design systems that leads to optimal learning (Sweller, 2011). According to CLT, the amount of information an inexperienced user can process is limited (Paas et al., 2004). Inexperienced users have a limited working memory and can only combine, contrast, and otherwise deal with a limited number of information elements and their relations.

CLT distinguishes between types of cognitive load that affect learning differently (Pass, 2004).[[1]](#footnote-1) The first type of cognitive load is an intrinsic load which is determined by the amount of information pieces and their interdependence (Sweller, 2011). The management accounting literature refers to task complexity to capture this idea. This type of load is necessary and unavoidable for learning to occur. If the user does not process the necessary information and the relation between different elements, they will not acquire new knowledge (Pass, 2004; Sweller, 2011). One prediction of CLT is that users will learn more when they have more information and the relation between different elements is more complex until the information overwhelms the user’s working memory capacity.

Management accounting studies have examined task elements and their interactivity. For example, additional performance measurement information at first increases judgement accuracy as users have more information available, but more information eventually decreases users’ performance (Shields, 1980; 1983). In the same vein, when a task is too simple, users benefit less from feedback compared to users who conduct task that is more complex (Masha, 2001). On the other hand, providing information in the form of feedback to the users does not always have positive effects on accounting decision making. When users do not have the skill to cope with a complex task, providing feedback on tasks actually decreases their performance (Ashton, 1990).

Similarly, other accounting studies also demonstrate that decision making accuracy decreases once a task becomes too complex (e.g. Otley and Dias, 1982; Iselin, 1988). For instants, Audit judgment quality decreases when the audit task becomes more complex with an increasing number of information cues and goal interactions (Bonner, 1994). Similarly, the positive effects of goal setting on performance decrease in more complex tasks (Hirst and Yetton, 1999).

**Extraneous Cognitive Load and MCS**

Different from intrinsic load, extraneous load is determined by the cognitive resources that are unnecessary to find and interpret the information elements. Cognitive load can be avoided by optimising the presentation of information (Sweller, 2011). Therefore, extraneous load is under the control of the system designers and needs to be reduced as much as possible (Paas et al., 2003; 2004) so that working memory can be devoted to process intrinsic load for learning.

In accounting literature, researchers have found that the manner in which information is presented can have a critical effect on knowledge acquisition. Cardinaels and Labro (2008) examine the effect of different levels of aggregation on measurement error rates and find that measurement error in an aggregated costing system (six input cues are aggregated into three) is lower than under a disaggregated costing system (as six input cues are defined). Highly aggregated information is well-structured and thereby easier for users to process. Compared to a stand-alone list, integrating strategic risk information in a balanced scorecard format reduces the extraneous load imposed on users so that the users are more likely to identify strategic risks from performance feedback, and make more accurate evaluation and recommendation on the company’s strategy (Cheng et al., 2018). In addition, visual indicators of whether measures are above or below targets simplify the presentation and help users to focus on all four perspectives (Cardinaels and van Veen-Dirks, 2010).

According to CLT, another way to reduce extraneous load on users is to explain the underlying features of a task with a completed example. The worked example explicitly shows users how the information elements linked so users can abstract the underlying structures from the example and use this knowledge to solve new tasks (Renkl et al. 1998; Sweller, 2011).

In the accounting literature, previous studies have found that such explanation can be given not only in up-front instruction (i.e. worked example) but also afterward as explanatory feedback. Immediate, step-by-step explanatory feedback improves student’s learning in a ratio-analysis task but outcome feedback without up-front instruction does not (Bonner and Walker, 1994) Feedback that explains the underlying structure of one task leads to better learning and better performance in another task with the same underlying structure (Earley, 2001; Moreno et al., 2007).

In summary, accounting researchers have adopted some aspects of Cognitive Load Theory and aimed to present accounting information in a manner that are most likely to result in the facilitation of schema acquisition and automation for users with different level of experience. Therefore, there is an opportunity to adopt these findings in designing MCSs to promote learning accounting knowledge.

**Coercive Control versus Enabling Control**

Control systems that limit the behaviour of users can improve users’ learning because the systems simplify a complex task. The limitations of behaviours help inexperienced users to avoid mistakes (Alder and Boys, 1996). As a result, coercive controls decrease the cognitive load of a more complex task which benefits especially inexperienced users.

However, a control system cannot always provide correct feedback due to change of operating environment (Chenhall, 2003), senior management’s lack of local knowledge (Wouters and Wilderom, 2008) or built-in bias and algorithm limitation (Ashton, 1990). In a changing environment users need to adapt to the environment and to circumstances unforeseen by the control system. Such an incomplete control system is argued to benefit from a more flexible design with the option for users to repair the control system when necessary.

**Flexibility and repair**

Flexibility provides users a right to explore and test control alternatives and the option to repair a system allows users to identify problems and to rectify errors in the current settings (Wouters and Wilderom, 2008). These customisations are specific to the local unit in which the user operates and makes temporary or permanent changes in the control system (Ahrens 2000). When inexperienced users learn about the control system and the task, they can incorporate the information in the control system, and rely on it for future decisions.

On the other hand, from the cognitive load perspective an inflexible control system or a control system without repair has automated many task elements so that inexperienced users do not have to cognitively process the information on their working memory. The user benefits from the task simplification and the cognitive load resulting from the control system decreases. Even through the literature generally believes that flexibility and repair facilitate learning, yet the factors that support or hamper knowledge acquisition is not well-understood. Some previous studies find that only flexibility or repair is not sufficient to achieve desirable learning outcome. For example, Jordan and Messner (2012) suggest that if users poorly understand the task or the functions of the control system, flexible use of a control system results in decision errors. We argue that internal transparency is a pre-condition for flexibility and repair to be successful.

**Internal transparency**

Internal transparency refers to whether users have access to information about the design of the system and its underlying structure of internal processes. Users are unlikely to acquire new knowledge through the system if they cannot understand and access the system (Adler and Borys, 1996). The management control system literature suggests that providing information of a task in a causal chain or a high use of causal language (i.e. expressed through “because” or “therefore”) in performance feedback enhances the users’ understanding of the underlying structure of the task (O’Donnell and Perkins, 2011; Cheng and Humphreys, 2012; Loftus and Tanlu, 2018) because it allows the users to build up a schema of how different information elements are connected. With inexperienced users, we argue that the success of using flexibility and repair to improve performance depends on a reliable and valid understanding why certain controls mechanisms are in place and what the underlying structure of a system looks like.

We argue that an internal transparent MCS reduces the cognitive load resulting from irrelevant information which intervenes with cognitive processing on inexperienced users’ working memory. Instead, the insightful information in explanatory feedback facilitates schema acquisition in users’ long-term memory. MCS users’ cognitive resource gets redirected from extraneous cognitive processes back to the task given explanatory feedback and user are more capable to use the flexibility and repair to learn. In order to successfully navigate this new information and build up a schema of the control system, internal transparency is a necessity for flexibility and repair to improve learning as it eliminates irrelevant information and keep total cognitive load under users’ capacity. Without internal transparency, flexibility and repair hinder inexperienced users’ learning as the total cognitive load is more likely to overwhelm their working memory. If MCS has no flexibility or repair characters, users’ learning suffers less in an MCS with no internal transparency than those who have flexibility or repair because the task to perform is less complex and automated by the MCS.

**H1**: Compared to inflexible systems, flexible control systems improve users’ performance more with internal transparency than in the absence of internal transparency.

**H2**: Compared to systems without repair, control systems with repair improve users’ performance more with internal transparency than in the absence of internal transparency.

**Multiple tasks and MCS**

Scholars have realised that firms now tend to adopt a holistic approach in job design and that jobs consists of a number of distinct and interrelated subtasks (Lindbeck and Snower 2000). The combination of multiple tasks allows employees to develop transferable skills over time and utilise the experience from one task to perform a more difficult task.

In MCS context, it is common that not all tasks are controlled by control mechanisms. Rather, enabling control mechanisms provide information on what should be paid attention and provide opportunities to improve task performance (Simon, 1995). For example, MCS users’ overall task performance increases when compensation controls are implemented on one task dimension and feedback controls are provided on the other dimension (Christ et al., 2016). With multiple tasks, incentives provided on one task spill over to positively influence another unrewarded task when MCS users perform the two tasks simultaneously (Hecht et al., 2012). Therefore, the amount of attention or information processing required by multitasking as well as the control system structure provided can have an effect on MCS users’ learning not only on the controlled task but also potentially the uncontrolled task.

Cognitive Load Theory suggests that simplifying the overall task can already help to free up cognitive resources for learning (Paas, 2004). Given that control mechanisms facilitate users’ learning with the controlled subtask, we expect MCS users are able to direct the free cognitive capacity to learn the more complicated task strategies even through it is not controlled directly.

**3.0 RESEARCH METHOD**

**Task description**

There are two phases of the experiment task. There is no control system in the first phase of the task and we introduce a control system in the second phase. The experiment task is adapted from Sprinkle (2000) in The Accounting Review. Participants have to decide on the quantity of production for one product. If they overproduce compared to the unknown market demand for the product, they earn zero profit. If they produce less than the demand, they earn a profit which increases with higher production. Market demand is unknown to participants and stays the same for five consecutive periods (i.e. one trial). After each trial of five periods, the market demand changes randomly. The participants need to take a decision for 12 trials for a total of 60 periods. Although participants are not told the demand, they are informed about and always have access to the profit for all possible combinations of market demand and production quantity during the task (see Table 1). Because participants are able to update their belief regarding the profit after each period and because demand does not change for five periods, they can potential learn the unknown market demand. For example, when a participant decides that production is 8 units and they gain no profit, they learn that demand is less than 8.

As participants go through the task, they can learn and form a strategy to maximise their profit. There are three features of the task that participants can learn and we discuss them in increasing levels of difficulty. Participants have to learn when to increase or decrease output based on the profit in previous periods. When profit in a given period is 0, they need to decrease production in the next period. When they receive a positive profit in a given period, they can increase the production quantity.

**Insert Table 1**

As a next step, participants should learn that 11 of the production quantities are dominated choices and never optimal (Sprinkle, 2000). For example, production quantity 12 and 13 produce the same profit as 11 when demand is less than or equal to 11 (i.e. 60 profit points). However, when demand is more than 11, choices 12 and 13 do not produce any profit whereas option 11 maintains the same profit (i.e. 60 profit points). Since the market demand is unknown, choices 12 and 13 are riskier than choice 11.

The most complex feature of the task is that participants should learn that their choices at the start of a trial of five periods with fixed demand reveal information about the unknown market demand. That is, when participant make a decision at the start of a trial they should not only maximise their immediate expected earnings but also the value of the information for the next four periods. Sprinkle (2000) showed that the optimal strategy starts with a production quantity of 14 because the risk of no profit (market demand < 14) is offset by the probability of knowing early on that demand is high (market demand ≥ 14). When the participants know in period one of five that market demand is high, they can profit from this knowledge for the next four periods.

**Control system and manipulation**

In the second phase of the experiment, we introduce a control system that helps participants avoid some of the dominated production quantities. When participants choose one of ten quantities, the control system will force them to choose another quantity choice. Given that a control system cannot always provide correct feedback, there are five of the dominated production quantities which are not detected by the control system, and four of the ten controlled quantities are not dominated by another choice[[2]](#footnote-2). The quantity choices that are controlled are greyed out in Table 1 as a visual reminder of the control system.

We use a 2 X 3 design where we manipulate (1) internal transparency (IT) or no internal transparency (NIT) and (2) no flexibility nor repair (NFR), flexibility (F), or repair (R). Internal transparency is manipulated by the feedback of the control system. With internal transparency, the control system will present and explain why a production quantity cannot be chosen, while without internal transparency, the control system will only tell participants they cannot choose the production quantity. For example, when participants choose production quantity 13, a message will show, stating “this production choice is not allowed because there might be other choices with the same profit points but a lower risk to overproduce.” In the no internal transparency groups, a message will be given to participants which only states “this production choice is not allowed” but no explanation given. Based on the feedback, participants have an opportunity to amend the final decision to choice 11 and avoid the simple mistake.

Without flexibility and repair, participants have to follow the control system and choose another production quantity in the control condition. In the flexibility conditions, participants have the option to override the control system and keep their original production quantity even through it is not allowed by the control system. When the participant chooses the same quantity in the future periods, the control system will show the same message to remind the participant on their suboptimal choice. In the repair group, a repair option can be used by participants when they decide the controlled quantity is actually optimal. Participants are not only given the option to override the control system but they can also rectify the control system. This means that the control mechanism on a particular output quantity is permanently “turned off” when the repair is executed, thus there will no longer be a prompt message when the participant chooses the same quantity in future periods. In addition, participants in the repair condition are allowed to “turn on” the control if they identify a choice as not optimal and there has not been a control in place.

**Task procedure**

Before the participants start, they will be instructed that they play a production choice task. The website will then show a short instruction and inform participants to make production quantity decisions to maximise their profit. When the experiment starts, participants in all six conditions will have the same treatment with no control system (i.e. no internal transparency and no flexibility nor repair) from trial 1 to trial 6 and the manipulation of internal transparency, flexibility and repair will be introduced in trial 7 onwards. After they complete the experiment task, a post-experiment survey is administered. A post-experiment survey is based on the instruments in Chapman and Kihn (2009) to verify the participant’s understanding of the manipulation and the data collected. Finally, participants need to complete the backward digit span task which aims at capturing participant’s working memory capacity. The experiment is designed to take no more than 60 minutes.

**Dependent variables**

Mistake 1 is the first measurement and it is measured based on how many simple mistakes against the underlying logic of the task a participant makes. As stated above, there are 11 production choices in Table 1 which should never be chosen because they give participants a higher risk to earn no profit[[3]](#footnote-3). The second measure is Mistake 2. Participants should realise that they can increase the production choice in the next period of a trial when they receive a positive profit and they should decrease the choice when they receive 0 profit in a previous period. If they fail to do so, we measure this type of mistakes as Mistake 2. Third, Change in performance which is the second-phase profit (trials 7-12) less first-phase profit (trial 1-6). This measurement is used to capture the effect of management control system on participants’ learning. In order to directly compare the performance before and after we introduce the control system, the set of states of natures is the same in the first and second stages (the order of states of natures is randomised within each phase)[[4]](#footnote-4). As a result, the potential total profit is the same in the first and second stages. Fourth, Total profit is calculated as the cumulative profit earned over 60 periods (12 trials). This measurement represents participants’ task performance.

**Participants**

Participants are recruited from the online platform, Prolific which offers participant recruitment services to behavioural researchers. The advantage of the online platform is that participants are recruited from a more representative and larger sample of potential participants and one of the disadvantages of online experiments is the greater variability in participant’s performance in the experiment (Woods et al., 2016). Nevertheless, prior studies with the same task showed already large variety in performance in an undergraduate sample (Hannan et al., 2008).

We take three measures to overcome the problem of potential large variety in our sample. First, we run a partial within subject design where we only introduce the manipulations in the second phase of the experiment. This allows us to control for individual differences in cognitive capacity and learning. Second, the online platform allows us to quickly and flexibly collect new data. Third, we will employ a sequential analyses which allow us to collect the data in different stages (Lakens, 2014). We will analyse the data after 15 participants per condition and then for every 5 additional participants per condition who have performed the experiment where we adjust the Type I error rate for the early look at the data. This allows us to stop the data collection early when the data provides either sufficient evidence for a either the null hypothesis or the alternative hypothesis.

We ran extensive simulations based on the effect sizes in Hannan et al. (2008) to validate our approach. We tested whether our partial within subject designed is able to detect a true effect better than the full between subject design in Hannan et al. (2008) and Sprinkle (2000). We find that with moderate to high variability our approach outperforms the full between-subject design. This is consistent with the finding in Bellemare et al. (2014). Our design has the ability to detect a true effect smaller than the Hannan et al. (2008) feedback effect 80% of the time with 35 participants per condition for moderate to high variability and with 50 participants per condition with extremely high variability. The principled sequential design allows us to take into account the risk of high variability while keeping the number of participants low if the variability is lower than expected.

**APPENDIX**

*Table 1: Profit for a given production quantity and demand with controlled conditions greyed out.*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Production Quantity | | | | | | | | | | | | | | | | | | | |
| Demand | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 5 | 5 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0. | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 5 | 5 | 10 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 5 | 5 | 10 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 5 | 5 | 10 | 20 | 20 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 0 | 0 | 0 | 0 | 0 |
| 16 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 95 | 0 | 0 | 0 | 0 |
| 17 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 95 | 95 | 0 | 0 | 0 |
| 18 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 95 | 95 | 95 | 0 | 0 |
| 19 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 95 | 95 | 95 | 100 | 0 |
| 20 | 5 | 5 | 10 | 20 | 20 | 30 | 30 | 30 | 45 | 45 | 60 | 60 | 60 | 80 | 80 | 95 | 95 | 95 | 100 | 100 |

1. In the original Cognitive Load Theory, there is a third type of load namely Germane Load. It is irrelative in this study as it focuses on the motivation of system users rather than the cognition of system users. [↑](#footnote-ref-1)
2. The six dominated production quantities controlled in this task are 2, 5, 8, 12, 13, and 18. The four production quantities which are controlled but not dominated are 3, 6, 9, and 16. [↑](#footnote-ref-2)
3. We alter the mistake 1 measurement in groups without flexibility or repair (i.e. IT\_NFR, NIT\_NFR) as participants in those groups cannot override the decision aid even though the original decisions provided are wrong and the choices should not be controlled. As such, when an optimal choice is controlled, participants in those two groups should choose a second best option. The second best option is still one of the choices which are not dominated by other choices (i.e. 1, 3, 4, 6, 9, 11, 14, 16, and 19) and it is the one next to and less than the optimal choice. [↑](#footnote-ref-3)
4. The states of nature used are 4, 6, 9, 11, 14, and 16. There are three main reasons to use these specific choices as the states of nature. First, these values for the production quantity form a part of the optimal strategy, so they should be used to facilitate learning profit maximisation. Second, it allows us to directly compare the performance of trials with the same state of nature in the first phase and in the second phase of the task. Third, since these states of nature are not dominated by other choices, they would make a difference when the control system is not perfect. For instance, since the state of nature 14 is a controlled choice, the participant cannot just choose 15 because that will give them 0 profit points and they will have to settle with 11 to earn a profit. [↑](#footnote-ref-4)