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The Connection between the Disconnects: Exploring Process Redesign to Reduce Human Error

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The Connection between the Disconnects: Exploring Process Redesign to Reduce Human Error

by

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Abstract

Title: The Connection between the Disconnects: Exploring Process Redesign to Reduce Human Error

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It has been said that organizations are only as effective as their processes. However, often times organizational behavior management (OBM) utilizes performance management to resolve issues as opposed to Behavioral Systems Analysis (BSA), which encompasses process redesign to ensure processes operate efficiently. Ultimately, to assist in long-term beneficial changes, process redesign could be helpful for allowing performers to have the resources to benefit from the enhanced process. However, little research has been done that assesses performance change with disconnects removed or with the addition of automation in a controlled laboratory setting. Thus**,** the current study examined the effects of a comprehensive process level redesign on the timeliness and quality of completing a simulated work task. The task was completed by college students in a laboratory setting. The redesign involved streamlining the process, eliminating waste, and integrating automation into the process. Results indicated that the process level intervention improved performance on measures of timeliness. However, there was no statistically significant difference with respect to number of errors. Areas for future research are discussed.

Keywords: behavioral systems analysis, process redesign, performance management

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Dedication

I would like to dedicate this thesis to my family. Your endless support has been invaluable.

My parents, Reid and Suzy,

My sister, Cassie,

My grandparents, Jim and Patricia, Waren and Carol

Introduction

Introduction

Performance management is a subfield of organizational behavior management (OBM) that focuses on improving employee performance through manipulating antecedents and consequences. However, organizational problems may be broader and require a comprehensive approach. Thus, the utilization of behavior systems analysis (BSA), an approach that includes broader level analyses at the process and organizational level could potentially lead to further performance improvement.

The Three Business Traditions and Some History

In order to better understand the different approaches to performance improvement (such as BSA and specifically process improvement), it would perhaps be helpful to first consider some history, specifically in relation to the three business traditions which are at the heart of effective process redesign. The first business tradition is the management tradition. The management tradition began with Geary Rummler and his contributions which precede the emphasis on quality regarding process enhancement as well as thorough utilization of computer programs to automate procedures. Rummler and Brache (2013) emphasized that utilizing process redesign may result in enhanced performance and furthermore argued that in order to further enhance processes, organizations should first improve individual performance within the process. The second tradition, quality control, transformed into Six Sigma emphasizing consistent process enhancements through statistical methods, measurement, and incremental advancements. Six

Sigma and Lean are included in quality control and the goal is to conduct frequent assessments of product output to identify issues *early* on in the process.

One component emphasized in lean is waste elimination. One common form of waste is motion and specifically employee movement which creates waste. Creating workstations resulting in little employee movement when performing various tasks could reduce waste (Harmon, 2008).

Considering six sigma and lean, according to Bond (1999), these two approaches enhance performance. The just-in-time tactic focuses on changing minor progressive developments to create a significant achievement. The other tactic, process re-engineering, focuses on restructuring a business process. Perfect technology helps ensure effective process redesign. For instance, perfect technology allows the restructure of a process that aims to produce unique structure and associate information systems throughout. This aligns with the third tradition, IT, which is composed of utilizing computers and technology to *automate* processes with an emphasis on applying online systems to assist in gathering information.

It can be argued that each approach described above is critical to improving organizational performance and that it is not just one approach, but a comprehensive approach that is needed to achieve the best results (Harmon, 2008). For instance, as Rummler and Brache (2013) pointed out, process improvement may be key. However, it is equally critical to ensure the individuals within the process are carrying out the tasks correctly and this is where the management tradition or PM fits. Additionally, integrating IT into the process and using automation when possible may help further reduce the likelihood of errors. Moreover, following the six sigma and lean approaches and making frequent incremental improvements early on in the process could further improve efficiency. Furthermore, removing unnecessary waste such as movement can further increase productivity. By incorporating a combination of these components comprehensively, the organization is able to enhance performance. However, while these traditions are often promoted in practice, little research exists in the OBM literature that specifically explores the effects of each approach or their effects in combination (Harmon, 2008). Thus, it would be interesting if future research evaluated the combination of effects.

The Need to take a Comprehensive Approach

While it may seem appealing to utilize one intervention or adopt the narrow perspective, it is essential to take a comprehensive approach as the more narrow perspective is limited to antecedent and consequence manipulation and lacks expansion to other areas. Additionally, not taking a comprehensive approach may result in overlooking the main issue as the consultant is not using all resources available. Furthermore, solely adopting a narrow perspective may be a mistake as the contingencies are often defined so specifically that change may not be long-lasting if the environment changes. This narrow focus may ultimately result in the organization failing to adapt. Alternatively, adopting a broader perspective allows one to adjust to environmental changes as it considers how the contingencies will affect other components in the organization (Rummler & Brache 2013).

Taking a broader perspective allows performance analysts to adopt a systems approach by broadly observing the various contingencies needed to create new methods for the process to prosper (Sulzer-Azaroff, 2001). Essentially, it could be possible that taking a broader perspective would allow one to identify a larger process problem. Correcting this larger problem could make the process more efficient so that the performer within the process could reach maximum output (Rummler & Brache, 2013).

However, as mentioned, one should not lose sight of the individual or behavioral contingencies within that process. While the broader perspective is ideal, the importance of the narrow perspective should still be incorporated. Specifically, a systems issue may also need behavior intervention. Thus, the analyst should make the appropriate adjustments to the system and then focus on employee behavior ensuring employees have the resources and capabilities to utilize the benefits of the improved process. Thus, narrowly observing the situation allows behavior analysts to identify the key features of the issue once the broader approach has identified the main issue. Both adjusting the process to be efficient and arranging contingencies at the performer level has been argued to be critical to ensuring maximum performance (Sulzer-Azaroff, 2001). However, while many systems experts have noted the importance of a broad approach that integrates process level and performer level interventions (Kelly & Gravina, 2018; Sasson et al., 2006), little research has been done that explores and compares the effects of each approach in isolation and each approach combined.

BSA as a Subfield of OBM

A subfield that focuses on process level changes as well as examines behavioral contingences within that process is known as behavioral systems analysis (BSA). To better understand BSA, it is perhaps helpful to examine how it relates to other disciplines within the field of Behavior Analysis. Behavior analysis as a discipline is composed of different branches with various subfields in each branch comprising different elements in those subfields. The different branches that encompass behavior analysis are experimental analysis of behavior (EAB) and applied behavior analysis (ABA). Included in ABA are subfields of OBM, developmental disabilities, and other subfields. ABA and OBM both focus on the prediction and control of behaviors regarded as “socially important.” However, OBM is specifically focused on enhancing the behaviors of people in an organization who contribute to the services created as well as enhancing manager behaviors as they assist in improving behavior (McGee, 2007).

OBM includes PM and BSA. PM focuses on adjusting employee performance and interventions focused at the individual level. BSA also assesses the individual level but extends further and also emphasizes process level and organizational level change (McGee, 2007). Overall, OBM utilizes the PM perspective by manipulating the environment correlated with specific behaviors as well as incorporating BSA, the more comprehensive approach. As mentioned, BSA has an emphasis on broader level variables including process level variables, but also examines variables related to employee behaviors when needed. Specifically, this technique investigates each level and improves processes where the major issue lies. BSA concentrates on adopting a comprehensive approach for creating an efficient system and occasionally adjusting employee behavior to create an efficient organization comprehensively (McGee, 2007). It could be beneficial to examine the effects of a system redesign to remove disconnects enhancing the system while adjusting employee performance as well.

By observing the organization from a broader perspective, the primary problem is evaluated as opposed to solving smaller issues that result in other similar problems in the future (Hyten, 2009). However, more research should be done to confirm this. Furthermore, the argument is not that BSA is “better than” PM, but rather that utilizing a comprehensive approach that involves PM level interventions as well as broader level interventions such as process level interventions (i.e., BSA) may be ideal. It could be that broader level interventions can further enhance the effects of PM by allowing an individual to perform a desired behavior within an efficient system. However, future research is needed to confirm that notion.

Performance Analysis

It is clear that a systems approach may be beneficial. Thus, it would be helpful to examine the approach in a bit more detail. BSA includes a heavy reliance on Performance Analysis to identify disconnects at all levels. To aid in identifying the issue, experts use organizational diagnosis, a technique to collect data regarding the organization's operation. Ultimately, organizational diagnosis involves examining the entire organization when identifying issues by considering the three levels: the individual, process, and organizational levels. It should also be noted that each level has a different tool or diagnostic model to assist in identifying core problems. Additionally, the main model used at the individual level for systems analysis is the Human Performance System. The major model utilized for the process level is process mapping (Austin, 2000).

Process mapping is a technique that visually demonstrates the series of actions completed to make a product or service (Diener et al., 2009). It has been said that organizations are only as efficient as the processes (Rummler & Brache, 2013). Thus, only changing individual level performance could result in sustained problems if a process is damaged. Therefore, process mapping demonstrates how processes operate across different functions which is important as products and services transfer through various departments to create the product or service. Consequently, individuals in the field have suggested the need for more applied studies with the three models. Systems analysis is an area that would benefit from more research but often may be overlooked given that, among other things, organizations can be complex. None the less, it is important to examine the applied situations when searching for methods to improve the company (Diener et al., 2009).

A Systems Appeoach to Performance Analysis

Hyten (2009) discusses the difference between two approaches in OBM, the behavior focused approach, similar to the performer level or PM, and the systems focused approach (BSA). The behavior focused approach is based on finding solutions for inappropriate behaviors or increasing appropriate behavior as opposed to identifying changes larger in scope. Additionally, with the behavior approach, there is frequently a lack of data regarding how the adjusted behaviors actually impact the bottom line. Thus, it is unknown if the change in performance resulted in the company being more successful, or if it simply changed employee behavior. Therefore, it could be interesting to assess results measures such as timeliness or quality. Sometimes, management focuses on bothersome employee behaviors rather than focusing on those that drive business success (Hyten, 2009). The critical aspects of the performance or systems problems can be ignored when evaluating smaller issues not of critical value.

To address this situation, the systems focused approach should be utilized as it is a more in-depth method. The systems approach provides context as it is a comprehensive view allowing individuals to see the main picture and identify necessary areas to intervene. Furthermore, another benefit of the systems focused approach is that it provides leverage, enabling one to identify numerous variables as opposed to being restricted to antecedents and consequences (Hyten, 2009). It could be beneficial to examine the effects of utilizing the systems approach with various variables and identify how that enhances current processes.

According to Hyten (2009), results are the focus of systems analysis. Utilizing a systems approach could influence important results measures such as time and cost while creating a more efficient outcome. It would be interesting to see if a system oriented-results focused approach saves time (Hyten, 2009). Additionally, given that results measures are critical, assessing quality measures associated with process level improvement would be ideal. However, little research has examined this directly and as such it is an area that is ripe for future research and exploration.

Along with positively influencing results, conducting a BSA helps create alignment for tasks within a company to deliver value-adding services to the consumers. Consumers are the ultimate reason an organization thrives. Thus, it is essential to analyze and adjust factors and processes that contribute to the value-adding services. BSA highlights necessary components that have value-adding aspects which are often identified through goals. Thus, it is important to ensure the analyst focuses on the goals the company is attempting to achieve, how work is completed, and the necessary components involved in the process. The three levels are the organization, job performer, and process level (Diener et al., 2009).

The Proces Level of Analysis

It is clear that research needs to be completed in the area of BSA. However, given that a systems approach is broad, it is critical to identify where to start. This process level may be a good place to start. A process is described as a chain of activities resulting in a cumulative product directed to a specific purpose (Rummler & Brache, 2013). One method that has been used to understand a process is cross-functional mapping and specifically creating IS and SHOULD or OUGHT TO BE maps that depict the organization's structure as well as the department functions (Malott, 2003). These process maps present the sequential steps that each department undergoes to transform inputs to outputs.

The IS map highlights the current state of the process and identifies disconnects through function interactions. Moreover, when creating a SHOULD map, it is important to recognize that the improved process version is the most effective for achieving goals (Rummler & Brache, 2013). It would be interesting to examine an existing IS process and then create an efficient SHOULD process and assess the impact that this has on performance. While experts have suggested the importance of designing efficient processes (Malott 2003; Rummler & Brache, 2013), little research has been done that specifically assesses the change in performance when comparing an IS process or existing inefficient processes with an ideal process or SHOULD BE process that has been streamlined.

Process Disconnect

The process level of analysis may be a good place to start when designing an intervention. With that in mind, it would be helpful to understand some common disconnects that are often seen at the process level of analysis. Ramias (2013) identified eight common disconnects that can contribute to an inefficient process. Each will be discussed in detail. The first disconnect is serial process steps. The serial component requires employees pausing at one step until employees upstream complete required steps prior to accomplishing steps farther in the process. However, this is inefficient and results in waiting which can be eliminated by creating a parallel process for multiple steps to occur simultaneously (Ramias, 2013).

The second disconnect is excess reviews, approvals, and inspections which should be evaluated to determine if each instance adds value to the process or if these excess tasks could be unnecessary (Ramias, 2013). Additionally, the third disconnect is unnecessary, non-value-adding steps including completing tasks twice, excessive processing, and waiting. If the step's purpose is debatable or confusing, its impact on the final output should be evaluated as a method to identify whether it is value-adding or should be removed. The excessive reviews, approvals, and inspections disconnect as well as redundant activities are described as non-value adding tasks (Ramias, 2013). Furthermore, the fourth disconnect is redundant activities described as repeating effort or completing identical tasks several times but in various places within the process. To that end, several departments could be completing the same tasks due to a lack of trust or communication between the other departments (Ramias, 2013). The fifth disconnect is batch processing, which could involve a holding region. These should be evaluated for insufficiencies as it can result in postponement of steps farther in the process (Ramias, 2013). The sixth disconnect is multiple process variations, which may be necessary for the complexity of various consumers or services. However, the analyst should examine if the variations can be combined to allow for a simplified process (Ramias, 2013). The seventh disconnect is bottlenecks which are occasionally inevitable and possibly not detrimental. However, they should still be observed when streamlining the process to identify if the bottleneck situation or the surrounding process can be enhanced (Ramias, 2013).

Finally, the eighth disconnect is rework loops, which are often a result of issues occurring earlier in the process, where steps repair the products from previous steps. This could be recognized when future steps need to repair the output through inspections causing reworks. This disconnect represents the cause and effect that each step creates and highlights the need for a visual process map to easily identify where changes occur. By identifying and resolving these eight disconnects, the process can become streamline and create an efficient organization (Ramias, 2013).

Building Technology into the Process to Overcome Disconnects

While Sasson et al. (2006) evaluated two process variations, the study failed to incorporate technology into the process to remove the disconnects. Technology is an important aspect to consider as companies utilize technology as a labor reducing tool and it could help to ensure there is a reduction of error. Presently, there exists a strong emphasis on the utilization of technology into a process as it is time and labor efficient (Brethower, 2001).

Likewise, elaborating on the importance of technology, according to Harmon (2008), the IT tradition expanded on the utilization and integration of software to automate systems and processes. Individuals employed in the IT tradition are merging workflow with software tools to create specific systems able to automate steps within processes. The IT tradition focuses on utilizing software to automate areas capable of automation and enhance efficiency.

To illustrate efficiency, automation was considered for the automated manufacturing research facility (AMRF) project, which hoped to construct and automate a machine shop for the production of metal components. To produce these metal parts, process selection was utilized which has the potential for automation. Artificial Intelligence computer system techniques were incorporated for automating process selection. To gather information regarding the part, an interactive system including questions and user answers would perform process selection, consequently, routing all or a portion of appropriate questions to other systems. Additionally, the system's information can be simply added or changed allowing a reasoning in process selection, thus representing the utilization of automation (Nau & Chang, 1983). This study highlights the use of automating areas capable of automation in a process redesign. Automation is an effective method to remove disconnects and eliminate human error and increase timeliness. However, little research has been done to automate systems and evaluate the effects. It would be interesting for future studies to create processes with and without automation to identify the changes in timeliness or quality.

Examples of Process Level Interventions

Correcting the aforementioned disconnects can allow for successful process improvements. For instance, Kriesen (2011) utilized BSA to evaluate the Print Product Management (PPM) system, a procedure that transfers printed materials to a printer, of an organization. The goal was to assist the company with alterations for a more efficient process as the process was outdated. The Total Performance System (TPS) and a Behavioral Systems Analysis Questionnaire (BSAQ) was utilized as a method to observe PPM as a process. A process map was previously created, and the analyst identified disconnects. The findings for the process-level revealed that critical steps were absent resulting in confusing print requirements. Costs were amplified, deadlines were missed, and products were of weak quality (Kriesen, 2011).

Some process level solutions included creating a cross-functional process map detailed with additional steps to create a streamlined process and remove any disconnects. Overall, results highlighted the benefits of creating an IS map to visually identify current disconnects and create a cross-functional SHOULD map to remove disconnects and create a streamlined process (Kriesen, 2011). While this study utilized process maps to remove disconnects, it did not incorporate automation into the process. As this study utilized methods to print products, automation could have been beneficial for further streamlining this process, eliminating the need for manual entry, and reducing the likelihood for human error.

Thus, future research should examine the effects of incorporating automation into process redesigns.

Gikalov et al. (1997) assessed the effects of a new method to schedule clients at an optometrist office. Patient scheduling has been suggested as a component for larger revenues and smaller costs. Thus, to adjust scheduling and efficiency, a systems method was utilized to enhance employee and doctor time by reallocating responsibilities. The procedure consisted of addressing the limited number of clients as well as marginal profits, possibly due to inadequate employees and weak scheduling. The intervention allowed for more appointments to be scheduled resulting in increased revenue and less appointments reserved per doctor hour. This study highlights how adjusting a process leads to a more efficiently operated organization (Gikalov et al., 1997). However, while this study utilized process redesign, this was not tested in a controlled laboratory setting and it would be interesting to examine in a controlled context.

Through the utilization of a process level intervention, Kelley and Gravina (2018) investigated extended Emergency Department stays as they resulted in amplified costs and displeased patients. Thus, in hopes to reduce unnecessary costs and enhance client experience, the goal sought to alter the current door-to-order length which was the time patients arrived to when employees ordered the initial radiology or laboratory examination. Consequently, researchers created an IS process map to portray the existing process. Results from the IS map indicated that only physicians were able to approve every order, but the nurses saw the patients in a faster manner than physicians. Researchers addressed this bottleneck by creating preapproved order sets for common symptoms and enabling nurses to enter these orders. This resulted in less time during door-to-order but also enhanced provider's productiveness due to fewer patient visits. They also incorporated feedback to the nurses as only few employees were following the adjusted process (Kelley &

Gravina, 2018). Feedback resulted in the nurses following the new process. While this study assessed the effects of addressing a bottleneck (one of the eight common disconnects), it would be interesting to assess the effects of addressing other common disconnects and doing so systematically. If the eight common process disconnects could be simulated in a laboratory setting, one could systematically assess the effects of intervening upon each individually or in combination. Furthermore, one could address these disconnects in a controlled manner which could create an original research line devoted to process level intervention.

Research does exist that applies experimental manipulations at the process level within a controlled laboratory setting. However, this research fails to assess the effects of removing common disconnects systematically. Comparing two process variations, Sasson et al. (2006) is the only study to examine the effects of process level changes, performance level changes, and the combined effects of both levels on the completion of a word processing task. Participants were required to complete the task of replicating a passage of text originally in electronic records to a word file. Two process variations were included and participants either received version one, the manual process, or version two, the electronic process. The manual process consisted of physically obtaining the electronic record from an alternative location compared to the electronic process which consisted of receiving the electronic record through email. Furthermore, the third condition, utilizing both the process and performer levels, examined the behavioral intervention phase which delivered specific performance expectations as well as a brief bonus contingent on achieving performance levels (Sasson et al., 2006).

Results indicated that for minutes-in-possession, the process intervention as well as the performer intervention led to a significant effect on the performance. Consequently, more research should be conducted as this is the only study to examine both the process and behavioral intervention interactions (Sasson et al., 2006). However, this study did not evaluate automation which could have resulted in a more efficient process redesign. Thus, future research should evaluate incorporating technology and automation into the process redesign.

The GAP and Need for Future Research on Systems

There have been few studies that specifically assess the effects of BSA or a comprehensive approach to performance improvement (Johnson et al., 2014). The lack of research could be due to successful results occurring without the assessments. However, identifying the issues through assessments may assist in maximizing behavior change through process redesign (McGee, 2007).

Furthermore, another factor that could contribute to the lack of assessment research is environmental intricacy. Complex environments tend to have extraneous factors resulting in a possible problem to identify functional relations. However, it is suggested that research could be conducted in a laboratory setting to control for extraneous variables (Johnson et al., 2014).

Johnson et al. (2014) classified BSA functional assessment studies into several categories including conceptual or theoretical, little empirical data, comparison with control, and control with alternative. Of the studies classified in this comparison, 31 articles utilized BSA, and from those, approximately 70% were conceptual or theoretical. About 25% of the studies offered little empirical data and only 3% included comparisons against control. Just one article included comparison against an alternative. Furthermore, as mentioned, Sasson et al. (2006) was the only study that attempted to validate BSA through experimental manipulations with a control as well as an alternative method due to the use of multiple comparisons. According to Johnson et al. (2014), most research utilized AB designs, which lack replication possibilities and do not reflect cause-and-effect relationships. From this research, it becomes clear that more studies are needed that assess the effects of BSA level interventions. Thus, the current study examined the effects of a comprehensive process level redesign on the timeliness and quality with respect to completing a simulated work task. The task was completed by college students in a laboratory setting. The redesign involved streamlining the process, eliminating waste, and integrating automation into the process.

Method

Participants, Setting, and Materials

Participants consisted of approximately 40 undergraduate and graduate students. There were 20 individuals per group. One participant in the control condition was excluded from the results as they encountered internet connection issues and did not follow the procedures. Thus, there were 39 participants in total, 19 individuals in the control condition and 20 individuals in the experimental condition. In order to participate in this study, participants were required to have access to a computer with video and audio capabilities and the ability to login to zoom and canvas. They also needed access to Microsoft Word and a strong internet connection. All research procedures received Institutional Review Board approval. This study was completed from the participant's homes through zoom.

Independent Variable

The independent variable assessed in this study was a process level redesign or an efficient process with disconnects removed. Specifically, an IS process for creating a canvas quiz had been created that contained several common disconnects mentioned above. Alternatively, a SHOULD BE, or streamlined process for creating the same canvas quiz had been created that addressed these disconnects and incorporated automation into the process when creating the canvas quiz.

Experimental Task

Participants were emailed quiz questions and copied and pasted 81-questions into a quiz on canvas. Thus, the output was a constructed quiz on canvas.

The control group entered the quiz using the IS process and therefore encountered these disconnects when constructing the quiz. The experimental group entered the same quiz questions but did so using the SHOULD BE or streamlined process with the disconnects removed.

Dependent Variables

Two dependent variables were assessed in this study. The first dependent variable was the timeliness measure or the total duration to enter the 81-question quiz under both the inefficient and efficient process. The second dependent variable was a quality measure (the number of errors made) under both the inefficient and efficient process. Quantifying the errors was a bit of a complex task as errors were not simply able to be counted given that each question type presented many opportunities to make a variety of different errors. For instance, it was possible to enter the incorrect point value for a question and also enter a duplicate answer within the same question (i.e., make two errors). Thus, if a participant completely skipped a question and failed to enter it, researchers could not simply count it as one error. For this reason, an original scoring system was developed. To develop this scoring system, the primary researcher did an initial cursory review of the quizzes to identify the most common and critical errors types. Each question was then rated based on quality and given a quality point score that took into account those common error types (See Appendix A). Each question could earn up to 4-6 quality points based on the question type. If the participant made no errors when constructing that question, they would receive full points. While the number of available points may have changed based on question type, the total number of quality points remained consistent across all exams. There was a total of 447 quality points available for constructing the entire quiz. If the participant failed to enter a question or transfer it to the quiz, they received zero quality points for that question and lost all quality points that were available for that question type since the question was never attempted. The total quality point score earned by the participant for entering all questions was then subtracted from the total quality points available on the quiz and this yielded the total number of errors based on all questions in their entirety.

While complex, this method failed to capture other critical errors that occurred that could not be found based on examining errors within a single question. For example, it is possible that the student entered duplicate questions. Thus, the researchers noted at the bottom of the data sheet if duplicates occurred and deducted one quality point. These errors were then added to the total error score that was based on each question type to generate a comprehensive error score that factored in multiple different error types. It is still important to note, however, that these data sheets included only the most common and critical errors. Some errors that prevented complete point-to-point correspondence between the master copy of the exam and the one generated were not taken into consideration. However, it is believed that assessing the most important errors would provide the most valid indicator of quality performance.

Interobserver Agreement (IOA)

Two forms of Interobserver Agreement (IOA) were collected for this study. The first form of IOA was Total Duration. Total Duration IOA was used to assess agreement on the timeliness measure. Two independent observers each collected total duration measures and then calculated Total Duration IOA by dividing the shorter duration by the longer duration for a single quiz and multiplying that number by 100 to get the total duration IOA percentage. The IOA calculated for duration was 99.81%.

The second form of IOA was total count IOA. Total count was used to compare agreement on the number of errors. Two independent observers scored the quiz using the quality points datasheet. The total number of quality points was subtracted from the total possible points that could be earned which resulted in the number of errors each participant made. The number of errors each independent observer found was totaled. The smaller number was divided by the larger number, and this was then multiplied by 100 to get the total percent of agreement. The IOA calculated for quality was 98.39%. Furthermore, IOA was collected for 33% of the sample and the minimum acceptable level of agreement was 80%. The percentage remained higher than 80% but if the percentage fell below 80%, retraining would have occurred.

Research Design

A between-subjects design was utilized to evaluate the effects of the process redesign on timeliness and quality when creating the canvas quiz. The participants were randomly assigned to one of two conditions. Each participant participated in only one of the conditions. The control condition contained common disconnects that led to an inefficient process. The intervention condition consisted of a process redesign to cover the following common disconnects: Steps performed manually that could be automated, Multiple Process Variations, Waste issues, Redundant steps, Unnecessary/Nonvalue adding steps. Many of these disconnects were encountered through the use of the forms (A-C) that the participants were copying and pasting questions from. The participant was told that they must copy and paste from the form exactly as shown and in the order in which the questions were presented. They were also given training on how to follow this process. They were not allowed to cut corners or work around steps. All sessions were video recorded through zoom. The remaining disconnects were encountered through the instructions and steps the experimenter gave the participant to follow when constructing the quiz.

The intervention condition performed the process described above with the disconnects removed. There were alternative forms (A-C) that were exactly the same as those in the first condition but were not numbered. These forms were used by participants in this condition. All disconnects named above were addressed to increase the efficiency of the process. In order to facilitate comparisons between the two conditions, one specific disconnect will be presented below that was applied to the control condition and following that, the correction for that disconnect that was applied to the experimental condition will then be introduced. The disconnects and corrections will continue to be presented in this manner until all the disconnects have been addressed.

Control Condition- Disconnect Type #1: Unnecessary Nonvalue Adding and Manual vs. Automated Steps

Completing steps manually can slow down a process and allow additional opportunity for error. The effects of this manual component can be easily assessed in the lab when creating a canvas quiz. For instance, it is common practice for instructors creating quizzes to randomize their answer choices to ensure there is an approximate equal distribution of A's, B's, C's, and D's. If, for instance, every answer was C, then this might decrease the validity of the test. Therefore, to simulate this in the lab, all correct answers were marked as A on the participant's forms. Participants in the control condition were expected to begin the process by *manually* rearranging the answers on the form so there was an approximate equal distribution of A's, B's, C's, and D's for multiple choice questions. Additionally, once the answers were randomized, participants then had to *manually* mark which answer was correct once the question was inputted into canvas.

Finally, on the control condition form, all numbers and letters were included, thus requiring the participant to remove the information once it was copied and pasted into canvas which created an unnecessary and non-value adding step.

Experimental Condition- Correction for the Above Disconnect #1

When possible, it is recommended that technology be integrated into the process to remove the manual component, minimize steps, and decrease the likelihood of human error. Rather than have to manually rearrange answers to get an equal distribution, canvas has a "shuffle answer" feature that automatically shuffles the answers. Thus, participants in the experimental condition did not have to randomize their answers manually and rather than performing this step, they simply clicked the "shuffle answers" option on canvas. Additionally, in automating the answer randomization, another manual component was also removed which was anticipated to further decrease the likelihood of error. Specifically, on the forms, the correct answer always began as answer A. In canvas, the correct answer always defaults to letter A. Thus, any answer entered in that row was recognized as correct automatically. Thus, the participant did not have to manually mark the correct answer but simply entered it as it was shown on the form, and it was automatically recognized by Canvas as correct. Using the "shuffle answers" feature then shuffled the response options so that while all correct answers started out as A, they were evenly distributed by canvas.

Additionally, the answer letters were also removed on the form as when the participant copied those into the quiz, the participant needed to remove the answer letter. Thus, an unnecessary nonvalue adding step was removed by removing the answer letters in the forms.

Control Condition- Disconnect Type #2: Multiple Process Variations and Manual Redundant Steps

As mentioned, a common disconnect is a multiple process variation. A multiple process variation involves creating the same output using a slightly different variation of the same process. Multiple process variations can be harmful given that if there are too many variations, it can cause confusion and errors. This disconnect can be easily simulated in the lab. Specifically, inputting each question *type* involved completing a slightly different series of steps (i.e., a slightly different process variation).

For the control condition, the participants were expected to rotate between entering each question type (true/false, multiple choice, and matching). Thus, for each set of three questions, the participant had to vary their process slightly from question to question. This consistent rotation between different process variations was intended to simulate a multiple process variation in the laboratory. Performing the same process slightly differently and rotating was also hypothesized to potentially increase time and errors.

Along with multiple process variations, requiring the participant to vary their process from question to question also led them to encounter another disconnect (i.e., redundant steps). Specifically, when switching from a true or false question to a multiple-choice question, canvas does not automatically add the number of answer options needed which required the participant to do that manually and was anticipated to take additional time.

Additionally, similar to a typical exam, different categories of questions were worth different point values. For example, true or false questions were worth 1.5 points, multiple choice questions were worth 2.5 points, and matching questions were worth 4.5 points. Thus, when inputting the question, the participant was expected to also enter the corresponding point value manually and continuously adjust the point value based on the question type. This constant rotating was anticipated to increase the likelihood of error. Moreover, the requirement to manually input the point value for each question was anticipated to take additional time.

Experimental Condition- Correction for the Above Disconnect #2

Participants were still expected to input each question type but inputted one question type in full prior to moving on to the next question type (e.g., all of the questions from the True or False form were entered and then the participant moved on to entering the multiple-choice form). This eliminated the need to rotate between forms and potential error associated with going back and forth. To do this, the participant utilized the question banks feature and inputted each question type into a separate bank. Then, at a later time, the participant set canvas to pull from those banks to construct one quiz, so the questions were sorted without the need to do it manually. Rather than inputting each point value manually for each question, also utilizing the question banks feature, the participant assigned point values one time for each question type at the end which was anticipated to save time and reduce error.

Control Condition- Disconnect Type #3: Multiple Process Variations, Unnecessary/Nonvalue Adding Steps, and Movement

Lean emphasized arranging a workspace so that materials are organized and accessible so efficiency can be increased, and less movement is needed. To simulate a waste issue in the lab and further highlight the earlier process disconnect with multiple variations, each question type was located on a separate form. Form A contained True or False questions, form B contained multiple choice questions, and form C contained matching questions. This was intended to simulate a typical work setting with multiple process variations given that, based on the process being performed, the materials to complete the different process variation could be located in a different area. Thus, rotating between process variations (or forms in this case) created additional need for movement which can be wasteful and was anticipated to take time. It should be noted that, while each question type was on a different form, to ensure the participants followed the inefficient process and continued to rotate as they were supposed to, the questions on the forms were numbered according to the order in which they are to be inputted into canvas. For example, form A contained True or False questions and they were numbered 1, 4 7, 10, etc. and form B contained Multiple choice questions and were numbered 2, 5, 8, and 11. This is to ensure the participant entered the questions as directed to fully encounter the process disconnect. Additionally, the participants were instructed to rotate between each form when each question was entered. They were able to have the forms and canvas side-by-side but needed to rotate between the forms for each question. This stimulated waste in organizations.

Experimental Condition- Correction for Above Disconnect #3

Participants in the experimental condition utilized the same three forms as the above condition but given that they were allowed to input each question type on each form in full and did not need to rotate between questions, they also did not experience the unnecessary movement associated with rotating between forms. They were allowed to input all of the questions on form A and then minimized form A and moved on to inputting all of the questions on form B and then minimized form B, and finally moved on to inputting all of the questions on form C. Given that they were allowed to input each question type in full, they did not encounter the additional wasteful movement from rotating between the different forms.

For this reason, the forms were not numbered, and the participants were instructed to input each question type in full and then move onto the next. Since they did not have to rotate and minimize out each time, they were also able to better position the form to further reduce movement and waste (a common lean approach) by setting up one's work area to be efficient. Specifically, they were instructed to adjust the form so that it was side-by-side with the canvas quiz and did not need to be minimized until entering the questions had been completed.

Control Condition- Disconnect Type #4: Rework Loop Waste, and Unnecessary Nonvalue Adding Steps

Another common form of waste is allowing an output to get far into a process prior to an error being caught and corrected or going through a rework loop. Six sigma emphasizes catching mistakes early on in the process. To simulate this in the lab, the control condition copied and pasted a quiz with errors into canvas and were expected to find and correct those errors after they had been entered. Specifically, there were 15 errors embedded in the different questions on the forms, each intended to represent a common human error that may occur when constructing a quiz. These errors were designed to be easy to spot when reviewing the quiz to ensure that all participants saw them. The errors included unnecessary underlining of the text in the question and unnecessary italic text. After the questions were inputted into canvas, the researcher stopped the clock. They asked the participant to exit out of all forms and the participant was told about the 15 errors and the nature of the errors. They were then briefly shown how to preview the quiz and edit it. They were asked to preview the quiz to find the errors, log the errors, and return to the quiz and then correct them on their quiz. The reason for the previewing is that, given the design of canvas, it is difficult to see questions that have been entered in full without previewing the quiz, thus creating an extra step if errors are not caught early on in the process. This was intended to simulate a typical work setting in which it was important to catch errors early on. To protect internal validity, participants were also told that they may not correct any additional errors they found beyond those 15 errors even if it was an error they made when entering the quiz into canvas.

Experimental Condition- Correction for the Above Disconnect #4

The same errors were embedded into the forms in the experimental condition. However, participants in this condition were instructed to find the errors and correct them on the form at the very beginning prior to inputting incorrect information into canvas. Correcting the errors in the beginning was anticipated to save time in having to preview the quiz and correct it later.

Procedure

Control Conditon

Answer Randomization

Participants were randomly assigned to either the experimental or control condition. The control condition began with being shown Forms A, B, and C (i.e., multiple choice and true or false tests). The researcher then read a script (See Appendix B). The script instructed the participant to randomize the answers so that there was an approximate equal number of lettered answers throughout the test (i.e., an equal number of A's, B's, C's, etc.).

Brief Training and Completion of Task

The forms were emailed to the participants prior to the study beginning. The researcher delivered a brief training on how to input the questions on the form into the various question types on canvas (True/False, multiple choice, or matching). Note that this training also covered how to adjust the point value for each question type as well as how to mark answers. Those in the control condition were given access to forms A-C with the numbers indicating the order in which the questions were to be entered. The researcher then read a script (See Appendix C). The script informed the participants that they must copy and paste from the form exactly as shown and in the order in which the questions were presented. They were not allowed to cut corners or work around steps. The script also mentioned that there may be errors on the form such as underlined or italic text, but the participant was still supposed to copy and paste the information exactly as it appeared on the form without making corrections. The script also told the participant to inform the researcher when they had completed the task. The timer was started once the researcher said begin and then stopped the timer when the participant stated they completed the task.

Editing and Error Correction

Once the participant completed the task, the participant exited out of the forms. The participant was then shown how to preview their quiz and return back to make edits. The researcher read a script (Refer to Appendix D) that informed them about the 15 errors, and they were told that they must preview the quiz, find the errors, log the errors, and then return to the quiz and make the edits to their quiz based on those logged. Once they made the edits to their quiz and informed the experimenter when they had completed the task, the experimenter stopped the timer and recorded the time.

Experimental Condition

Editing and Error Correction

The participants began this condition by reviewing the forms and correcting the 15 errors prior to inputting the information into canvas. The researcher began by reading a script (Refer to Appendix E) that told them about the 15 errors. The researcher began the timer when they instructed the participant to begin and stopped the timer when the participant said they had completed this portion of the study.

Brief Training and Completion of Each Question Type

Given that the participant did not complete each question type soon after training (i.e., they inputted one question type first and then moved onto the rest) it was believed that training of all question types at once may lead to delays given that they would not be able to perform the task immediately after. Thus, participants in this condition received a short training on one question type such as True/False, input that question type, and then received a short training on the next question type, input that question type, and then a final training on the final question type and inputted that question type. The researcher read the scripts about the training procedures (Refer to Appendix F). The researcher ensured that the total amount of time spent training was equal across conditions and no additional practice opportunities were offered between conditions. The timer was started once the researcher said begin and stopped the timer once the participant stated they finished. The researcher began this condition by reading an introduction script.

Answer Randomization and Point Value Assignment

Once the questions had been entered, the researcher did a brief training on how to upload the questions from question banks into a quiz, randomize the answers, and assign point values. The researcher read a script about this procedure (Refer to Appendix G). Once the training was complete, the researcher timed the participant to determine the amount of time it took the participant to upload the questions from each question bank into the quiz and assign point values. The amount of time spent training was not included in the total duration. The reason was that, although there may be some additional time spent in training in the beginning to use technology features (there may be more time up front), the benefits typically far outweigh the cost of this time through timeliness or quality. These benefits may not be easily seen in the first unit of product alone after the training (i.e., first exam constructed), but through time across multiple product units, the benefits may outweigh the costs. Thus, given that this study was assessing the creation of one exam, these benefits would not be fully realized if the time commitment for training was included. However, it was still possible to observe the amount of time saved on the task once the training was complete after observing completion of the first unit of product which was what was assessed in this study. Once the participants submitted their quizzes, the permanent product quizzes were assessed for errors and the total errors were recorded for each condition.

Social Validity

A social validity questionnaire was administered at the end of the study to examine if the streamlined process with the disconnects removed resulted in a more efficient process to create the canvas quiz (refer to Appendix H).

Results

Results

A non-parametric test was conducted to identify the difference in duration and quality for the control and experimental group. This test was selected as it was believed that it would be most appropriate due to the small sample size (N = 39).

A Mann- Whitney U Test revealed a statistically significant difference in the total number of minutes to enter the quiz for the control process (Md = 103.17, n = 19) and the experimental process (Md = 58.34, n = 20), U = 31.00, z = -4.458 p = <.001.

Additionally, A Mann-Whitney U Test revealed no significant difference in the total number of errors in the control process (Md = 5.0, n = 19) and the experimental process (Md = 4.5, n = 20), U = 202.500, z = .353, p = .728.

Discussion

Discussion

The present study assessed the effects of a comprehensive process level redesign on the timeliness and quality with respect to completing a simulated work task. The task was completed by college students in a laboratory setting. The redesign involved streamlining the process, eliminating waste, and integrating automation into the process. The following common disconnects were manipulated in the study: steps performed manually that could be automated, multiple process variations, waste issues, redundant steps, and unnecessary/nonvalue adding steps.

It was predicted that, given the nature of this particular process and the fact that the redesign condition utilized technology to a large extent and eliminated the need for manual entry, it would reduce the amount of time spent and number of errors. The results revealed that a process redesign significantly reduced the amount of time needed to input the quiz. The median number of minutes spent was a difference of approximately 45-minutes less in the intervention condition compared to the control condition. However, despite inputting the quiz much more quickly, this did not lead to a statistically significant difference in errors. This suggests that the process redesign enabled the experimental group to complete the task more efficiently without leading to more errors. However, while errors did not increase, the streamlined process also did not lead to a reduction in the overall number of errors as predicted. It is possible that specific types of errors that may have been highlighted by the process redesign would show a statistically significant difference. For instance, it is believed that there may be a statistically significant difference in the number of errors made due to having to click the correct answer. The experimental condition completely removed this human component and thus no errors were made while anecdotally, errors occurred in the control condition.

However, more statistics will need to be run to confirm this. While there was not a statistically significant difference in the number of errors, it is good to note the common errors made in each condition. Common control condition errors included not correcting the point value and not changing the correct answer. Common errors for the experimental condition included duplicating information.

There may be some reasons as to why a statistically significant reduction in errors did not occur. Specifically, one reason may be that many errors were not created in general possibly due to the task not being extremely difficult. Thus, it may be interesting to search for techniques to increase the difficulty of the task. Additionally, it is possible that Canvas could have streamlined the process to make it user friendly when creating the quiz process which could explain why both conditions did not make many errors. Also, another reason could be due to practice effects. These effects can occur when an individual completes similar steps repeatedly. This may have occurred as the participants entered 81 questions. It is possible that after several questions, the participant created a routine for themselves about the order to input each component. For example, the participant could have decided to input the question type first, then change the point value immediately after which could create a habit. This repetition may have reduced errors for both conditions.

Furthermore, it is worth noting that occasionally, the automated element may have led to opportunities for additional error. Recall that to decrease the likelihood for errors associated with point value, the question banks feature was utilized. This feature allowed participants to simply enter the point value for each question type once when transferring the question type into the question banks instead of manually adding the point value for each question when creating the quiz. Thus, canvas would then recognize and pull those questions and assign the correct point value. If an error was made, however, and the participant failed to transfer the questions over one time, then they would not be included in the quiz and could not be scored. This feature, which was meant to increase the ease of the task and reduce errors could actually lead to more errors.

This was observed on two occasions. Specifically, one participant failed to click “create question bank” and did not transfer any of the multiple-choice questions into the quiz. Additionally, another participant failed to click “create” and thus failed to transfer the true or false questions to the quiz. Given that they were not transferred into the quiz, the questions were unable to be scored. Therefore, the one error of failing to transfer the questions led to 27 questions missing for each participant and essentially many more errors.

One may argue that these questions should have perhaps still been included when scoring the quiz due to them having been constructed. However, for practical purposes, and to increase the external validity of the study, they were not considered because had this been an actual exam created by a professor for students, the previously mentioned error would have been dire as the students would not have been able to complete questions that were not moved from the bank to the quiz itself. Thus, although automation may be intended to increase efficiency, it should be supplemented with good quality control procedures. In other words, the participants should have been able to self-evaluate the quiz and get feedback. While training about how to construct the quiz was provided, without consistent feedback, training does not always maintain.

These additional errors were not evident through the statistical analysis conducted given that, due to the small sample size, a Mann- Whitney U Test was run (rather than an Independent Samples T-Test) given the small sample size. The present statistical test used the median to assess differences rather than the mean and thus would not have been affected by these two outliers. If outliers were considered, it is entirely possible that there would have been a statistically significant difference in a countertherapeutic direction showing that the process redesign led to more errors.

This may cause one to draw the conclusion that the process redesign was actually not as beneficial. However, recall that the median indicated slightly fewer errors than the control condition and thus, *overall*, it did not have this effect. With all of this in mind, a reasonable conclusion may be that a process redesign may be helpful. However, the use of automation could possibly increase the number of errors for individuals indicating the benefit of supplementing this with feedback as well as additional techniques utilized in PM. In the case that the participants could have received feedback in the form of previewing their quiz, these errors may have been corrected. While feedback may have contributed to additional time, the quality would potentially have been improved. Also, the time difference was substantial enough that we believe there would likely still have been a reduction in duration with the more efficient process and the opportunity to preview the quiz or receive behavior specific feedback.

Furthermore, process redesign is extremely valuable. This task led to a substantial time difference, and this was for one unit. Professors typically input a large number of quizzes over the course of a semester. Improving this process is increasingly important especially with classes and quizzes moving online. Furthermore, many professors in behavior analysis may do frequent quizzes which would increase the number of times they have to complete this task and correspondingly the duration of time spent. Reducing the time needed to complete the quiz task through a process redesign would enable the professor to dedicate their time to other areas. However, while this task was chosen, results would likely generalize to other professions that followed an efficient versus an inefficient process. A paper engineer, for instance, may be able to save time by inputting the product requirements into a machine to mix the paper and the machine would automatically then complete the tasks. While this automation may save time, if the specifics entered had the potential to be entered incorrectly, it could lead to more error and, correspondingly, increased waste.

Social Validity

Social validity measures were conducted in the form of a survey. Eighteen individuals completed the survey for the control condition and 19 participants completed the survey for the experimental condition. This was due to a couple people not completing the survey as well as the researchers excluding one participant in the control due to internet issues. For the control condition, the majority of participants did not believe the process was confusing. Additionally, Seven out of the 18 participants (38%) that completed the survey noted that believed they made a lot of errors. Nine out of 18 people (50%) thought the process was cumbersome. Furthermore, ten out of 18 people (55%) thought the arrangement of the rotating forms was inconvenient. fifteen out of 18 (83%) people in the control condition thought the task was tedious. Additionally, ten out of 18 people (55%) thought creating the quiz was inefficient. Thirteen out of 18 people (72%) thought there were unnecessary steps.

For the experimental condition, 19 out of 19 participants (100%) thought entering the quiz was not confusing. Additionally, 19 out of 19 people (100%) did not feel that they made a lot of errors. Only six out of 19 individuals (32%) thought the process was cumbersome. Thirteen out of 19 people (68%) thought the arrangement of forms was convenient. However, 12 out of 19 participants (63%) thought the task was tedious. Furthermore, 0 out of 19 participants (0%) thought the question banks feature was confusing. Eight out of the 19 people (42%) thought creating the quiz was efficient. Thirteen out of 19 individuals (68%) did not think there were unnecessary steps when creating the quiz. It would have been interesting to allow the participant to try each process separately and then fill out the social validity questionnaire after they had a comparison.

Overall, both conditions did not believe the quiz was confusing. However, a majority of both conditions also believed the task was tedious. This may be due to each condition not having exposure to the different condition. Thus, the experimental group may believe the task was tedious since they were not aware of how the task could be more tedious in the other condition. Additionally, a majority of people in the control condition believed there were unnecessary steps. Furthermore, the experimental condition did not believe the question banks were confusing, which is helpful information as question banks led to less time and movement.

Limitations

While the number of current participants allowed for statistical tests, the small sample size was a limitation for the current study. The sample size consisted of ($N = 39$) participants. Thus, future research should focus on obtaining a larger sample size. Additionally, as this study was conducted online, the internet connection is a limitation. A few participants' internet connection was lost and they needed to rejoin the session once the connection reconnected. In these instances, the researcher would pause the timer and then resume the timer once the connection reconnected. Furthermore, another limitation is that no treatment integrity measures were collected which would confirm that the procedure was carried out as it was intended to be. It is possible that certain participants in the inefficient process skipped steps or failed to rotate and it is also possible that students in the experimental condition may not have followed the efficient process as intended. Collecting measures of treatment integrity would have provided more information.

Future Research

Future research should assess the effects of a PM component. It is possible that PM could help further reduce the errors and may lead to statistically significant results. It also is possible that PM could further reduce the amount of time needed to complete the quiz. Considering specific PM techniques, feedback may be an option. The researcher could remind the participants to ensure they completed each step prior to clicking “update”. Self-evaluative feedback could also be used by allowing the participant to preview the quiz.

It would also be interesting to assess the effects of adding incentives. It is possible that incentives would further reduce the amount of time needed to complete the task and further decrease errors. Ideally, the effects of each component should be assessed systematically (e.g., inefficient process vs. efficient process, inefficient process vs. efficient process combined with PM, inefficient process plus PM vs. process improvement alone, etc.). Additionally, the process could be streamlined in multiple different ways such as reducing variations as in the present study, eliminating a bottleneck, converting a serial to a parallel process, etc. Essentially, a line of reasearch can be developed that is dedicated to systematically assessing the effects of process improvement and performance mangement interventions in the laboratory and the present study provides the first step.

Conclusion

Conclusion

The current study explored process level improvements which involved systematically removing disconnects and incorporating automation. Examining results measures is important for companies as quality and timeliness could cost a company money and resources. Thus, it is beneficial to identify methods to improve result measures. Utilizing an improved process appears to be one method that leads to desirable results on measures of timeliness which could save money.

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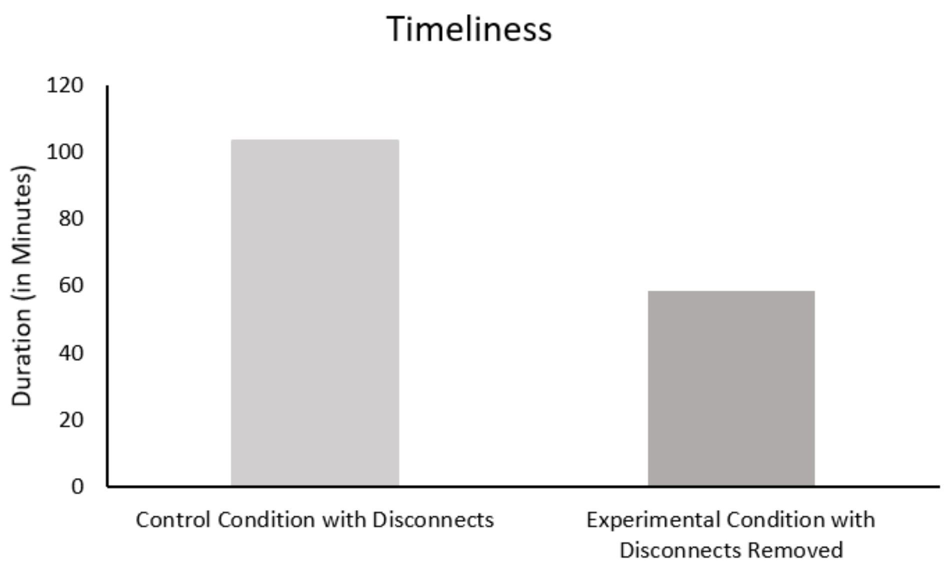
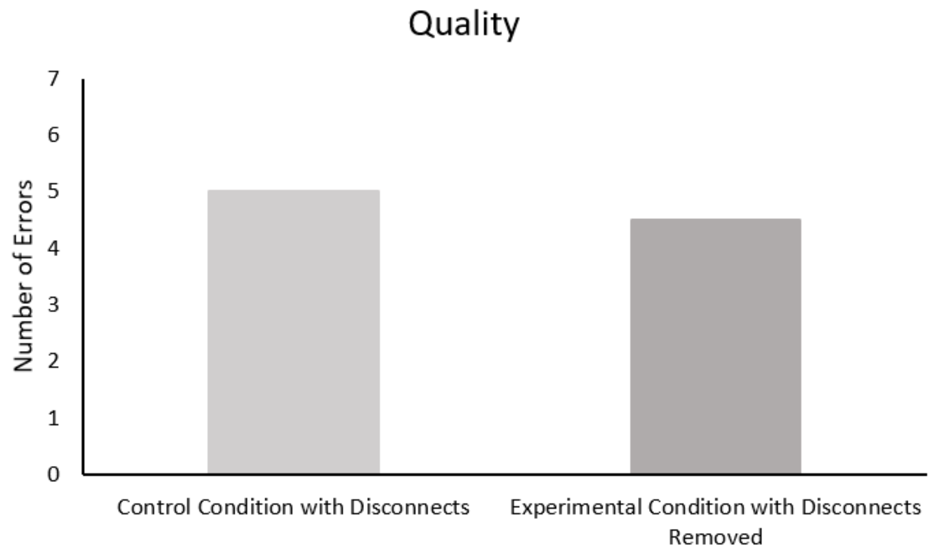
Figure 1: Average Time Spent on Creating Canvas Quiz



Note. The median duration spent on creating the canvas quiz per condition. The light grey bar on the left is the control condition median duration of 103.17 minutes. The dark grey bar on the right is the experimental condition median duration of 58.34 minutes.

Figure 2: Amount of Errors during Completion of Quiz



Note. The median number of errors made during the creation of the quiz per condition. The light grey bar on the left is the control condition of five errors. The dark grey bar on the right is the experimental condition of 4.5 errors.

Appendices

Appendix A: Quality Points / Error Datasheet

Participant code:	
Control (To be scored in quiz itself)	
Question 1 (TF)	
Formatting Did not include Letters or Numbers (all or none)	/1
Correct question type (TF)	/1
Correct point value (1.5)	/1
Selected Correct Answer:	/1
Corrected errors (if applicable)	/1
Total quality points earned for this question:	**/4**
Question 2 (MC)	
Formatting Did not include Letters or Numbers (all or none)	/1
Correct question type (MC)	/1
Correct point value (2.5)	/1
No duplicate answers (all or none)	/1
Included all answer options (all or none)	/1
Selected Correct Answer:	/1
Corrected errors (if applicable)	/1
Total quality points earned for this question:	**/6**
Question 3 (Matching)	
Formatting Did not include Letters or Numbers (all or none)	/1
Correct question type (Match)	/1
Correct point value (4.5)	/1
No duplicate answers (all or none)	/1
Included all answer options (all or none)	/1
Selected Correct Answer:	/1
Corrected errors (if applicable)	/1
Total quality points earned for this question:	**/6**
Duplicate Questions: Subtract one point for each question	

Appendix B: Answer Randomization Script for the Control Condition

You will be entering a quiz into canvas. Prior to doing so, I would like you to first randomize your answers for the multiple choice questions. Currently, every answer on your quiz form is marked as A. (Show the participant the quiz form). However, I would like you to arrange it so that there are an approximate equal number of A's, B's, C's, and D's (similar to an actual quiz). Please note that the answer itself should not change; the same word should be bolded. However, the positioning of the answer should change. For instance, if the answer TAG teach is marked as A. The answer will still be TAG teach, but it will be moved so it will be another letter so there is an approximate equal distribution of A's, B's, C's, and D's. Here is how you can randomize. First, if you are moving the correct answer to B, highlight the answer option click and drag the option to the end of the new answer choice (move to end of C for example). Then, separate the two answer options and press enter. Then go to the empty excess answer option under that and delete it. Last, go to answer A and delete that (demonstrate that). So now you can see that TAG teach is still bolded but is marked as C. You will repeat the process for all of the questions on the multiple choice form. Also, you will repeat this process for the true or false questions. Currently, true questions are presented first, and false questions are presented after. Please randomize the questions. (Have them practice one question). Now that you have practiced, please randomize all of the answer choices. Are there any questions? Please get my attention when you have competed the task.

Appendix C: Training Script for Control Condition

You must copy and paste from the 3 forms exactly as shown here. There may be some errors throughout the forms such as underlined text or other errors, but you should copy and paste the information exactly as it appears on these forms and as modeled. Do not start yet. I will let you know when to begin. You must copy and paste from these forms exactly as shown here and in the order each question is presented.

The questions are numbered in the forms. You must correspond the question number on the form to the question number on canvas. For instance, question number 4 on the form must match question number 4 on the quiz. You will be rotating between the forms and canvas. The question types will be rotated to simulate a typical canvas quiz. I want you to enter the questions in the correct order. Question #1 is TF, question #2 is MC and question #3 is matching etc. The order is TF, MC, matching, back to TF.

Share screen and show how to enter questions Script

Let's begin entering the questions. I will show you how to do it, then you will practice. Please wait to start until after I should you. I am going to share my screen and pull up the TF, MC, and Match PRACTICE forms. You have TF, MC, and Match PRACTICE forms open. You will start by putting the forms side by side. Please make sure they fit the screen appropriately. So you have canvas on the left side and TF on the right side.

Go to quizzes. Click "+ Quiz". Click Classic Quizzes. Click submit. Click the "questions" tab. Click "+ new question". You will start by copying question #1 which is TF. For question number, delete question and put the pound sign and the question number (#1). Change the type to click true or false. Add the point value. Copy the entire question including the number. Delete the number. Click the green arrow for the correct answer. You cannot go back after clicking update. Min the TF form.

USE THE MC TEST FORM YOU SAVED WITH RANDOMIZATION! Now onto question #2 which is MC. You will max MC form and put the forms side by side. For the question number, delete the question and add #2. Change the question type to MC, change the point value. Copy and paste the entire question. You will need to erase the question number from the question. Copy and paste all answer options. You will need to erase the letters (a, b, c, d). Continue for each answer option. Click "+ add another answer" and paste D. Click the green arrow for the correct answer. Click "update questions". You may not edit once you click update question. Minimize MC form.

Now you will enter matching question #3. Max Matching form. For the question number, delete the question and add #3. Click matching and paste the instructions. Add the point value. Do not paste the word instruction. Pull up the match form and fit the form appropriately on the screen with the quiz. Copy and paste the instructions. Not the word instruction just the other information. Copy and paste the term on the left. Copy and paste the definition on the right. After entering some answer options, canvas lists some suggestions, make sure the answer copied is the answer you copied and not a suggestion. You will need to click "+ add another answer" for the 5th term. Once the terms and definitions are pasted for that question. Click "update question" when you are finished with the question. You may not edit once you click add question. Min match form.

Now, you will go back to TF to copy question 4 and repeat the process. Once you have entered all of the questions click save. Any questions?

Now that I have shown you how to create the quiz, let's have you practice**.** I will stop screen sharing. Please share your screen and pull up the three PRACTICE forms. You will practice one question each. (they will practice questions 1-3. Give feedback on any errors.)

Now that you have practiced, exit the PRACTICE forms. Now please pull up open TEST forms and the MC form with randomizations. Create a new quiz and repeat the entire process that you just practiced. Please wait until I instruct you to begin. Let me know when you are finished. Any questions? Ok, ready… begin!
Now that you have finished, please exit the forms. You will no longer need these forms. You can stop screen sharing.

Appendix D: Editing and Error Correction Script for Control Condition

Now that you have entered all of the questions, I would like you to correct the errors in the test. There are questions with italics and underlined text. Please note that you are not allowed to change any errors you may have made only the previously mentioned errors. Please wait.

(Do not screen share. Go to your practice test and add underlined text to question #2.)

I will share my screen and show you how to edit the errors. To preview quiz: click “preview”. Scroll through the quiz and find the errors. You need to scroll through and preview to see the entire question to see the entire error. You can see that here that question #2 has underlined text. Once you have scrolled through the entire quiz and found all of the errors, scroll up and click “keep editing this quiz”. Click “questions” and click the pencil icon on the errored question, use the “I” and “U” icon to correct the error and click “update question”. Once you have corrected all of the errors, click “save”. Now that I have shown you, let’s have you complete this. I will stop sharing my screen. Please share your screen. Let me know when you have finished. Ready... begin!

Appendix E: Editing and Error Correction Script for Experimental Condition

You will be entering a quiz into canvas. You will have three test forms. True or false, Multiple choice, and matching. Prior to doing so, I would like you to first correct the errors in the test. Errors include italics and underlined text. You will highlight the entire document and click the I icon twice to remove the italics and the U icon twice to remove the underlines in the tool bar. You will repeat this for each form. I am going to share my share to model it. I have the true or false TEST form pulled up. (show how to do it). I will exit the form and stop screen sharing.

Share your screen and pull up each TEST FORM and edit them. Make sure you share your computer screen not a specific screen. Wait to begin until I tell you. Let me know when you are done by saying "finished." (they are ready). Ok ready… begin! (start timer).

Now please save the forms and exit out of them! you will be using these for the rest of the study. You may stop screen sharing.

Appendix F: Training and Complete Question Type Script for Experimental Condition

<u>Introduction to Training Script:</u>

Now that you have removed errors, I would like you to begin entering the quiz into canvas. I will show you how to enter one question type, you will practice that, then you will enter all of those type questions. This will repeat for the rest of the three question types. I will **share my screen** now.

<u>True or False Training Script:</u>

I will begin by training you on how to enter true/false questions into canvas. You will just watch right now. I will let you know when to begin.

I have my TF PRACTICE form pulled up. Click quizzes and "+ quiz". Click "+ Add question bank". Enter three question banks: TF, MC, Matching at the same time.

Click the TF question bank and click "+ Add Question". Do not worry about the question number. Simply click true or false. Do not put in the points for each question. This will be completed later. Minimize canvas and minimize the true or false PRACTICE form so you can place the pages side by side for easy viewing. Make sure the forms fit appropriately on the screen. Adjust as needed. Copy the TF question and paste into canvas. Click the correct answer and click "update question". Once you click update question, you will not be able to go back and edit.

Continue each TF for all of the questions. I will exit out of the form and stop sharing my screen.

Let's have you practice one question using the PRACTICE form. Share your screen. Open the TF PRACTICE form. You will only need that form open. Please wait to start until I tell you. Lets have you practice. Ready… Start! (participant practice). Now that you have practiced, exit out of the practice forms. Open the TF TEST FORM with the errors removed and enter all of those questions into canvas.

Wait to begin until I tell you. Let me know when you are done by saying "finished." (they are ready). Ok ready… begin! (start timer). (Have them stop screen share). You can exit the form and stop screen sharing.

Multiple Choice Training Script:

Now for entering multiple choice questions. I will share my screen. I have my MC PRACTICE form up. Click the back button and return to the question bank page. Click on the MC question bank. click "+ Add Question". Again, please do not worry about the question number. Simply click multiple choice. Do not put in the points for each question. This will be completed later on. Have canvas and the multiple choice form minimized again. Copy the MC question and paste into canvas. Copy and paste each answer option. You will need to click "+ add another answer" for options C and D. "+ add another answer" will only need to be clicked for the first question. Canvas will them automatically leave 4 options. You do not need to worry about clicking the correct answer. Click “update question”. Continue the process for each MC question. I will exit the form and stop sharing my screen. Let’s have you practice this. Share your screen and Open the MC PRACTICE form and enter one question (have participant practice).

Now that you have practiced, please go ahead and open the MC TEST form with the errors removed and enter those questions. Wait until I say start.

Wait to begin until I tell you. Let me know when you are done by saying “finished.” (they are ready). Ok ready… begin! (start timer). You can exit out of the form and stop screen share.

Matching Training Script:

Now for entering matching questions. I will share my screen. I have my Match PRACTICE form up. Click the back button and return to the question bank page. Click on the matching question bank. click “+ Add Question”. Do not worry about the question number. Simply click matching. Do not put in the points for each question. Have canvas and the match form. Copy the instructions and paste into canvas. Copy the term and then paste the term into canvas. Copy the definition and then paste the definition into canvas. You will need to click “+ Add Another Answer” for the last terms and definitions. Once all the terms and definitions are pasted, click update question. Let’s have you practice this. I will stop screen sharing and you will share your screen. Open the Match PRACTICE form and enter one question (have participant practice). Ready… start! You can exit the practice form.

Now that you have practiced, please go ahead, and open the Match TEST form with the errors removed and enter all of those questions into canvas.

Wait to begin until I tell you. Let me know when you are done by saying "finished." (they are ready). Ok ready… begin! (start timer).

You can stop sharing your screen and exit out of all the forms.

Appendix G: Answer Randomization and Point Value Script for Experimental Condition

Now that you have all the questions entered into canvas, I will show you how to upload the question banks into a quiz, randomize the answers, and assign point values.

I will share my screen. I have all three test forms pulled up. Click “quizzes”, click “classic quizzes” click “questions” and “+ new question group”. Click “link to a question bank”.

Click TF and “select bank”. Pick 27 questions for 1.5 points. You can find the point value on the question form. Please ensure you match the points to the selected question bank. Click “create group”. Repeat this for the other forms. Click MC etc. You will now randomize the answers by clicking “details”. You will then Click “shuffle answers”. Click “save”. I will stop sharing my screen.

Share your screen and PRACTICE on your TEST question banks. Ready… start. Now complete this test. Let me know when you have finished. Ready… start.

Appendix H: Social Validity Survey

1. Did you think the process you followed for entering the quiz was confusing?

1 2 3 4 5

Not at all confusing Very confusing

2. Did you feel you could have been making a lot of errors?

Yes

No

3. Did you think the process was cumbersome or inefficient?

1 2 3 4 5

Not at all cumbersome Very cumbersome

4. Did you feel that your work station set-up (arrangement of the forms) was convenient?

1 2 3 4 5

Very inconvenient Very convenient

5. Did you find this task to be tedious?

1 2 3 4 5

Not at all tedious Very tedious

6. Only answer this question if you were taught to use question banks. Did you think learning about those features of Canvas was confusing?

1 2 3 4 5

Not at all confusing Very confusing

7. How efficient was creating the quiz?

1 2 3 4 5

Very inefficient Very efficient

8. Did you think there were unnecessary steps when creating this quiz?

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree