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Intervention Development: Incorporating Behavioral Change Techniques (BCTs) into an E-learning Intervention

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Abstract - _Interventions which are grounded on theories are believed to produce more potent and sustained changes in behavior. This paper demonstrates the process of incorporating theory-based strategies into an e-learning intervention as guided by the Intervention Mapping Protocol (IMP) framework. Behavioral Change Techniques (BCTs) were translated into intervention components and were consolidated into the online platform. This process culminated into an e-learning self-administered tiered instructional module intervention. The intervention was administered to 31 operating room nurses of a selected hospital in Cebu, Philippines. An increment was seen in the median e-learning self-efficacy scores of the participants, from 66 during the pretest to 72 during the posttest. Wilcoxon Signed-ranks test was used and a significant difference was determined between the scores with p<0.05 at 95% level of confidence (z=-3.303, p=0.002). This finding was attributed primarily to the incorporation of theories through the BCTs in the e-learning intervention. This study suggested that computer-based interventions may be developed using frameworks based from behavioral theories and that the product of this creative process may lead to detectable changes in behavior. Furthermore, the intervention developed in this study may be used in the academe to better prepare the learners for online learning._

Keywords - _Behavioral Change Techniques, E-learning, Intervention Development, Intervention Mapping Protocol, Theory_

INTRODUCTION

The use of e-learning modalities to augment the surgical competency of nurses in the operating room has been widely advocated. E-learning can deliver courses to improve knowledge and skills needed to provide quality care. Studies show that it can decrease learning time by up to 35% [1] and is more advantageous than the conventional methods due to flexibility and low cost [2]. It is however important for nurses to develop the confidence to use e-learning platforms before they can harness the potential of this technology [3]. Developing an intervention to improve e-learning self-efficacy is imperative.

For an intervention to be effective, it has to be infused with theory-based strategies. Theories are believed to be the potent components of intervention which makes it work [4]. Thus, there is a need to systematically incorporate theories when developing interventions. The Intervention Mapping Protocol (IMP) offers a potential template for intervention development. However, most of the publications utilizing IMP emphasized more on the sequential process of creating an intervention rather than on providing details of linking the theory-based strategies. There is scarcity of literature to date which relays the development of an e-learning intervention using the IMP framework. Literature was consolidated by the author to give a glimpse of the knowledge base on e-learning in the context of health care, and the intricacies of an intervention development framework which was used as a blueprint in creating an online intervention.

The use of e-learning modalities in the field health care is widely advocated. In the operating room setting, the use of e-learning platforms for surgical training of staff is highly recommended to address the limitations posed by fast nurse turnover and shortage throughout the Philippines [5]. The majority of novice nurses need to augment their limited experience with additional knowledge and competencies which can be delivered by e-learning courses [2]. The use of e-learning modalities can also decrease learning time by up to 35% [1] which makes it advantageous in a time of short supply and high demand for manpower. It is important however that nurses have e-learning self-

efficacy [3] so this technology may be harnessed to its full potential. Exposing nurses to interventions to improve e-learning self-efficacy is a prerequisite to engaging in e-learning. This will allow the stakeholders to take advantage of the technology for its full benefit.

There are considerations in the development of an intervention to improve e-learning self-efficacy. For it to be effective, it must be based on theories as there is a known reciprocity between theories and interventions: Theories make interventions potent, and interventions refine theories. Theories are used to predict or determine viable strategies to produce an outcome (improvement of e-learning self-efficacy). Some scholars even consider strategies based on theories as the "active ingredients" of interventions [4]. As such, these theory-based interventions were expected to produce larger and more sustained effects in behavior change. Prestwich, Webb, and Conner [6] further emphasized the need to incorporate theories systematically into interventions for it to be effective. Being unable to do so may lead to interventions with varying effects or even make it less effective at some point. There is however scarcity in literature demonstrating the development of an intervention, much less, those stemming from e-learning platforms.

The Intervention Mapping Protocol (IMP) offers a framework for a systematic development of interventions[7]. It consists of sequential steps initiated by a needs assessment and culminates with an evaluation of the intervention. Along the process of intervention design and production, the IMP imposes techniques to embed theory-based strategies into the intervention. The author has published a paper which demonstrates the utilization of IMP in intervention development [8]. This article shifts the focus on the incorporation of theories. Theories are intricately weaved into the intervention by mapping intervention components to Behavioral Change Techniques (BCTs). Several scholars have published lists of BCTs such as Kok and colleagues [7] which ease the use of the process. There were several publications which indicate the utility of IMP in developing interventions[9,4]. However, most of these articles revolved on the sequential steps of IMP rather than on detailing the incorporation of theories. Furthermore, there was also no article to date which uses the IMP in creating an e-learning intervention.

The Intervention Design phase of the Intervention Mapping Protocol (IMP) directs the developer to select appropriate Behavioral Change Techniques (BCTs) to incorporate into the intervention. BCTs are specific strategies extracted from theories which are expected to elicit change (such as improvement of e-learning self-efficacy). Heath et al. [4] refers to this as the translational process of aligning theoretical constructs to intervention mechanics. Theoretical frameworks for improving self-efficacy include the Social Cognitive Theory, Theories of Self-regulation, Attribution Theory, and the Self-efficacy Theory of Bandura. BCTs which may be extracted from these theories include Guided Practice (facilitated rehearsal and repetition of behavior), Enactive Mastery (incremental difficulty of task), Provision of Contingent Reward (giving encouragement relative to accomplishment), Goal Setting (planning of behavior) and Setting Graded Tasks (giving indicators of capability). The BCT Guided Practice, for example, was obtained from Social Cognitive and Self-regulation theories which presume that constant repetition of a task with feedback will enhance self-efficacy.

The BCTs are general strategies as they were obtained from abstract theories. In the Intervention Production phase of the IMP framework, the selected BCTs are converted into concrete intervention mechanics. Based on experience in developing e-learning interventions [8], the author suggests the need to be familiar with the features of the platform as this is an important prerequisite in matching BCTs to e-learning functionalities. As an example, the BCT 'Contingent Rewards' requires the use tailored messages as feedback mechanism to the user. The intervention developer must know if the e-learning application is capable of a tailored-messaging system.

There are several e-learning platforms which may be used to develop an intervention. The author of this paper gained experience in using the Edmodo application as a faculty teaching the advanced informatics course at Cebu Doctors' University. Ekici[10] recognized Edmodo as a relatively simple and secure online platform for learning. It is an application that allows sharing of files, accessing virtual libraries and creating profile. Ekici [10] conducted a case study on the use of Edmodo among pre-service teachers who are transitioning to practical teaching. The use of Edmodo allowed the teachers to educate more effectively. The software is simple to manage which enhances their confidence to use computers. It also allowed better communication and collaboration. Some limitations though were presented such as the need for internet access and poor

compatibility with some mobile devices. Overall, they found Edmodo to be effective in improving the skills of the participants despite limited time for internship and practical courses as this online environment created an opportunity for professional development even outside the classroom.

Several scholars have provided guidance in the use of the Intervention Mapping Protocol (IMP) in developing interventions. Most of these publications tackle more on the sequential process of IMP rather than on the detailed assimilation of theories. Furthermore, there was no IMP-based intervention described to date which is e-learning in nature. Heath et al. [4] created an intervention to facilitate medication compliance in a hospital pediatric unit among clients with poorly managed asthma. The BCTs selected by Heath et al. [4] to address poor medication compliance were delivered through workbooks, tailored messages, and online links. Verbestel et al. [9] developed an obesity prevention program in Europe, named as the "Identification and Prevention of Dietary and lifestyle-induced health Effects In Children and infantS (IDEFICS)", using the IMP blueprint. The BCT Implementation Intentions (defining specific plans of action) was incorporated into the intervention by encouraging the participants to keep track of their behavioral patterns using diaries.

Self-efficacy has been a subject of research since 1970s but it was not until 2008 that online self-efficacy was conceived and further deliberated in scholarly articles [11]. Bandura [11] defined the term as the belief in one's capability to execute a task. This conceptualization is translated into the online environment as the confidence to use computer and related technology, navigate the internet, and utilize e-learning platforms. These 3 domains of e-learning self-efficacy emerged as themes in a literature review conducted by Alqurashi [11]. The Modified E-learning Readiness Assessment Tool captures these determinants of e-learning self-efficacy [8]. The tool was adapted from the work of Doculan [12] who determined the e-learning readiness of students and teachers in the Philippines. She noted that the tool is developed for countries which are not fully "e-mature". It also garnered good psychometric properties upon administration in the local setting.

This article demonstrates the intricate process of incorporating theory-based strategies into an e-learning intervention anchoring on steps imposed by the IMP. The presentation will highlight the process of selecting appropriate Behavior Change Techniques (BCTs) to improve e-learning self-efficacy, aligning the BCTs to e-learning features, translating the BCTs to intervention components, and merging the components into an e-learning platform. The effect of the intervention developed to e-learning self-efficacy will also be determined.

OBJECTIVES

This article aims to demonstrate the process of incorporating Behavioral Change Techniques (BCTs) into an e-learning intervention utilizing an intervention development framework. It also evaluated the effect of the intervention to the e-learning self-efficacy of operating room nurses in a selected hospital in Cebu, Philippines.

MATERIALS AND METHODS

Intervention Development and Evaluation

The intervention design and production process imposed by the Intervention Mapping Protocol (IMP) was employed in this study. Behavioral Change Techniques (BCTs) were selected from the published work of Kok et al. [7] based on its alignment with the features of the e-learning platform. BCTs which can be implemented in the e-learning software environment were chosen while those which are not applicable were discarded and not incorporated into the intervention. A matrix was made to match the BCTs to the specific e-learning activities. The intervention components where then consolidated into the e-learning platform. The product of this development process is a self-administered tiered instructional module intervention which can be delivered through a mobile device or personal computer. The users are registered into the e-learning platform and are given a set of tasks, each succeeding one being more complex than the previous. It involves self-paced activities such as navigation and identification of icons, to ones which are interactive such as downloading and message feedback. The placement of each module together with the online-based tasks for the users was based on self-efficacy theories such as that of Bandura.

The paper, incorporated with the developed e-learning intervention, was submitted for ethical review by the institutional ethics review committee and was given the protocol code 2019-040-Aventurado-OperatingRoom. The study was granted approval for implementation on February 27, 2019. A final report of the study was provided to the ethics office without modifications and ethical clearance was secured on

April 8, 2019. Transmittal letters were forwarded to the dean of Cebu Doctors' University Graduate School and to the hospital administrator of the selected hospital for permission to conduct the study.

The intervention was administered to 31 operating room nurses using a one group pretest-postttest design. The participants were ushered into a secured conference room and were given access to the e-learning modules through a tablet. Data were collected at baseline and after exposure to the intervention with the use of the Modified E-learning Readiness Assessment Tool (MERAT). The MERAT reveals a score range from 16 to 80 with higher scores indicating higher e-learning self-efficacy. Wilcoxon Signed-ranks test was conducted to determine for difference between the pretest and posttest scores. Kolmogorov-Smirnov test S test revealed that the scores were not normally distributed (D=0.194, p-0.005). Data were processed using IBM SPSS version 22.

RESULTS AND DISCUSSION

E-learning Intervention

Behavior Change Techniques (BCTs) to improve self-efficacy were extracted from the published work of Kok et al. [7]. The identified BCTs and the reference theories were reviewed. A manual for Edmodo e-learning platform was obtained and read. Intervention mechanics were developed based on the features of the e-learning platform and were matched to appropriate BCTs. Table 1 presents a matrix showing the alignment of the BCTs and specific intervention components.

The BCTs for self-efficacy were translated into its e-learning counterpart by familiarization with the platform features and operationally transforming each into an intervention component which can be loaded into the platform. Furthermore, the developer ensured

that each individual component would fit seamlessly and can be administered in an orderly manner. For this example, the BCTs for self-efficacy operate once the user logs into the platform and receives the 4 instructional modules.

The final intervention developed was a self-administered tiered instructional module embedded into an e-learning platform. Users were initially registered into Edmodo and sent 4 modules (set of files clustered together in a folder within the platform interface). The modules are numbered and must be complied according to sequence. Each module contains files which present the objectives and the tasks to accomplish by the user. The first module contains the general instruction and rationale for the intervention. The second module contains instructions that require the user to navigate through the interface. The third module tasks the user to use the platform tools and functionalities. And the fourth module requires the user to download and upload files from within and outside the platform. Generally, the tasks get more complex for each succeeding module. Self-efficacy theories suggest that the experience of using the application and exploration may increase the confidence to utilize such modality.

The BCTs Cue Altering and Goal Setting were derived from the theory of Automatic, Impulsive and Habitual Behavior, which presumes that providing signals to individuals to positive courses of action will prompt them towards that direction. These theoretical concepts are carried out in the module by presenting to the users the rationale for the intervention and the need to improve e-learning self-efficacy through the Orientation module and objectives for each.

The BCTs Guided Practice and Enactive Mastery are strategies to improve self-efficacy which emphasizes the importance of perceiving accomplishment in performing tasks at with incremental complexity. An individual who believes in his or her own capabilities to resolve a task despite the difficulty would be more confident.

Table 1. Behavior Change Technique - Intervention Matrix

BCT	Mechanism to Improve Self-efficacy	E-learning Intervention Component
Cue Altering	Rationalizing the need to achieve task	Orientation module
Goal Setting	Planning of activities to achieve task	Archived objectives per module
Guided Practice	Rehearsal and repetition of task	Archived instructions per module
Verbal Persuasion	Encouragement through messages	Tailored messages to motivate the user
Graded Tasks	Appraisal of task achievement	Tailored messages to relay task/s done
Enactive Mastery	Gradual increment in task difficulty	Increasing complexity of task
Contingent Rewards	Provision of rewards for achievement	Point-based incentive for achievement
Reattribution Training	Identifying attributes in terms of failure and success in task accomplishment	Not applied
Public Commitment	Announcing the desire to accomplish the task to others	Not applied

This was operationalized in the intervention through the self-directed instructions accompanied by feedback mechanisms. This component of the intervention was based on the concept of Learner Control as introduced by Bandura [11] which was defined as the self-initiated ability to implement technology-assisted instructions. This sense of control is important in attaining contentment and confidence in tasks at hand. A study conducted by Taipjutorus, Hansen, and Brown [13] on an online course revealed a positive relationship between learner control and online self-efficacy (r=0.393, p<0.05).

Lastly, the BCTs Verbal Persuasion, Graded Tasks and Contingent Rewards operate through the principle of self-efficacy which links provision of rewards to achievement of specified behaviors. Bandura [11] highlighted the impact of positive remarks to improve self-efficacy. This principle was implemented in the intervention through tailored messages which provides the user notifications on the number of tasks accomplished, encouragement to proceed to the next module, and positive remarks such as "Job Well Done!".

Effect of the E-learning Intervention

The effect of the e-learning intervention developed through the Intervention Mapping Protocol (IMP) was determined by seeking for significant difference between the pretest and posttest e-learning self-efficacy scores of the 31 participants exposed to the intervention. Table 2 presents the data as processed by the statistical software.

Table 2. E-learning Self-efficacy Pretest and Posttest Scores

Administration	Median	z-value	p-value	Effect
Pretest	66	-3.103*	0.002	-0.56
Posttest	72			

Significant

The participants obtained a median score for e-learning self-efficacy of 66 during the pretest (ranging from 43 to 78), which increased to 72 during the posttest (ranging from 53 to 80). The median scores among the respondents were at the higher end of the spectrum indicating high e-learning self-efficacy. These findings may hold true with the current trend of fast staff turnover at the hospitals leading to a younger generation of nurses as the workforce. This batch of care providers have been taught in a curriculum that incorporated courses such as nursing informatics which may have exposed them to various modalities similar to e-learning [14]. In further support, Fung [15] considered the youth as "digital natives" who are familiar with computer functionalities. This sector of the population is expected to harness the advantage of computer technology.

The difference between the pretest and posttest scores was found to be significant with p<0.05 at 95% level of confidence (z=-3.303, p=0.002). This implies that the e-learning intervention was able to produce an effect to the e-learning self-efficacy of the participants. This finding may be associated to the incorporation of theories into the intervention using the Intervention Mapping Protocol (IMP). Theory-based interventions are believed to have more potent impact on behavior, as theories can predict outcomes or the course of a phenomenon [4]. Prestwich, Webb, and Conner [6] also pointed out that studies with inconsistent incorporation of theories may have unpredictable or less effective impact. This limitation has been set off by using the IMP as the framework for developing the intervention. A notable portion of the IMP involves aligning Behavioral Change Techniques (BCTs) which are strategies extracted from theories. Merging the BCT to the intervention is an important step to ensure of its potency. Furthermore, there needs to be transparent reporting of how the BCT was incorporated and its rationale to appraise how the process was done. This was demonstrated in this paper.

In another perspective, interventions also may not be as effective if theories addressing multiple constructs are used. Authors do not suggest combining theories as this may reduce effect size and render the intervention atheoretical [6]. The use of the IMP process however countered this limitation as the Behavioral Change Techniques (BCTs) were consolidated to address similar constructs, such as e-learning self-efficacy. Several stages of refinement were also done in the IMP process before the final intervention was implemented. This was done in this study by aligning the appropriate BCTs to e-learning self-efficacy construct with consideration to the target population and objectives of intervention.

CONCLUSIONS AND RECOMMENDATIONS

This study was anchored on the premise that interventions grounded on theories produce potent and sustained changes in behavior. To make a suitable proxy for this notion, the Intervention Mapping Protocol (IMP) was used as a blueprint in making an intervention to improve e-learning self-efficacy. In

particular, the Intervention Design and Production guidelines imposed by IMP facilitated the incorporation of theories. The significant effect of the intervention to the e-learning self-efficacy of the respondents was highly attributed to this essence of the IMP framework.

It was also seen in this study that theories which are meant to modify behavior may also be translated into a computer-based intervention. An important prerequisite in creating an e-learning intervention is familiarity with the features of the platform to be able to translate the Behavioral Change Techniques (BCTs) into appropriate intervention components. The developer must integrate the different facets of the intervention seamlessly and systematically in an e-learning platform.

Overall, this study further supports the idea that interventions which are built upon theories have an anticipated advantage in terms of effect. Behavioral theories are also compatible with computer-based interventions which can attain changes in behavior.

There are some notable limitations of this study. The e-learning intervention was administered to participants who are categorized as "digital natives" based on age. This population group are thought to possess familiarity and more experience in using computer technology which may have influenced their adaptation to the intervention. Also, the translation of the behavioral components of the theory into the e-learning platform was based merely on the description and overview of the theory in psychology concept as there was no explicit guide in literature as of the time of writing this paper.

The proponent of this work strongly recommends for program developers and educators in the online environment to implement strategies which are based on theories. This will ensure optimum utilization of online resources and achieve expected outcomes. There must also be transparency, and clear and detailed documentation of intervention development to facilitate replication and modification if necessary. This study also relays the importance of e-learning intervention, with special relevance to the current shift to online education and remote means of living, in preparing the users in dealing with the online platform.

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P-ISSN 2350-7756 | E-ISSN 2350-8442 | ASEAN Citation Index
Asia Pacific Journal of Multidisciplinary Research, Vol. 8, No. 4, November 2020

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