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A Digital Model of Full-Cycle Training Based on the Zettelkasten and Interval Repetition System

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Abstract

The study aims to propose and validate a new digital model based on the Zettelkasten and interval repetition system for comprehensive and full-cycle training of the students. The core idea is to enhance the learning experience and effectiveness of the given training course by enhancing the student's attention during the learning and long-term information retention. In pursuit of the aforementioned research aim, the study incorporates a quantitative research methodology by combining experiments and a survey. In particular, the effectiveness of the proposed model was assessed via an achievement assessment involving two groups of students and assessing their scores on the same test. This was followed by a metacognitive awareness survey of the two groups to investigate their perceived understanding and performance (with and without the use of a model). The proposed model was found to be effective in enhancing the learning experience and effectiveness of the students on the training course. The Zettelkasten facilitates the management of the student's attention, while the interval repetition system contributes to increased retention. The students that used this model in their learning and preparation scored better than their peers. Also, they reported a significantly higher understanding and awareness of their learning than their peers. The model can be incorporated into the learning process or the provision of training courses to the students. This study is the first to suggest the integration of Zettelkasten and the interval repetition system into one learning model for the students. The article proposes a practical model that can be incorporated by teachers to improve the learning effectiveness of their students. This article has some limitations as well that must be acknowledged.

Keywords:

Digital Model; Full-Cycle Training; Zettelkasten; Interval Repetition System; Learning Effectiveness; Hyperfocus; Student Performance; Student Attention; Information Retention Learning Experience.

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1- Introduction

Training is an important part of most organizations, as they aim to enhance the skills and capabilities of the learners. Organizations can ensure that their workforce is competent and optimized to serve their needs through an efficient training system. However, it is also important to ensure that the training and development of the learners have the desired benefits [1]. It has been noted that training does not always bring the desired benefits because people's learning is not effective. In this regard, it is essential for organizations to have an effective and efficient training cycle that can help

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people learn optimally. Through this practice, the professionals can learn skills and abilities for their own and their organizations' long-term benefit. Zettelkasten and the interval repetition system are two key concepts that have a significant impact on people's learning. Through the application of these concepts, organizations can ensure that the learning and development of the learners are as per their needs.

The Zettelkasten technique is a unique, strategic way for individuals to think and write. It may be best characterized as an organization system that assists people in organizing their information while working, making it one of the most efficient knowledge management strategies (studying or researching) [2]. The Zettelkasten technique is outstanding because it not only facilitates the storage and organization of information but also enhances memory and knowledge retention. Creating knowledge linkages increases memory recall greatly and educates the mind to recognize patterns. Similarly, interval repetition is another important idea to enhance learning. Spaced (interval) repetition is an effective method that enables people to memorize things much faster than they normally would [3]. The goal of spaced repetition is to avoid trying to cram all of the information into the brain at once by spacing out repetitions or review sessions. Hence, these methods are highly effective in enhancing the learning process. Also, the trend toward digital learning and development has increased rapidly in the past few years. Despite its effectiveness, there is very limited research on the Zettelkasten and interval repetition system, as the studies have been conducted mainly in languages other than English and in academic settings. There exists a profound research gap in the practical relevance of Zettelkasten and interval repetition systems within the academic setting, as updated literature is not found in abundance, representing a critical lack of the latest insights related to the training and learning methods of the students. Due to this, this study examines the effectiveness of a digital model of full-cycle training based on the Zettelkasten and interval repetition system.

2- Literature Review

2-1- Zettelkasten Technique

Zettelkasten is a technique that was used by a German scholar, Niklas Luhman, which is also known as Slip Box [4]. Studies have shown that this German scholar was highly productive as he used the Zettelkasten technique for learning and development [4, 5]. Luhmann gave several distinct explanations of his Zettelkasten. He referred to it as a conversation companion at times and as a second memory, a cybernetic system, a ruminant, or a septic tank at other times. The Zettelkasten technique has been found to be more efficient and effective than note-making [6–8]. People use various methods of making notes, like paper notes, mind maps, smartphone apps, etc. However, studies suggest that the impact of these methods of making notes is not very effective in learning as they do not help people connect with ideas. The Zettelkasten approach pushes people to draw connections between many streams of knowledge and thinking [9]. The processes make it easier for the learners to naturally make new connections between ideas, which expands their knowledge and boosts their production. Through these connections, the concepts are engraved in the long-term memory of the people [10]. Additionally, Zettelkasten is also referred to as a knowledge management system, which acts as a framework for organizing thoughts, ideas, and information [11]. People may reproduce a stream of thought by associating ideas and linking facts (through hyperlinking) with one another. Thus, the retention of information is improved by creating connections between bits of knowledge, which then allow people's thought processes to develop naturally.

2-2- Internal Repetition System

People are not aware of the phenomenally effective memorizing method known as the Spaced Interval Repetition (SIR) technique, which was mostly created in the 1960s. Memory is a complex aspect of human beings and is very complicated to understand. Most individuals need to practice something numerous times before they truly understand it; this is how knowledge is transferred from short-term memory to long-term memory [12]. According to research, the optimum moment to review anything is just before people are about to forget it, like those formulas for statistics class. It is obviously quite challenging for people to predict when they will forget a crucial piece of knowledge. With SIR software, like Supermemo and Mnemosyne, the program strategically represents knowledge to people at precisely the right moment so that they may rapidly drill and practice what they are learning. The program learns how quickly you forget information. Due to this, the internal repetition system has high effectiveness in the training of the learners, as it enables them to be trained at the right intervals so that the knowledge is shifted from their short-term memory to their long-term memory [13]. This enables organizations to make their learners proficient in various skills and enhance their performance.

2-3- Digital Model of Full-Cycle Training

Training is an important process that is conducted in organizations to enhance the skills and abilities of the workforce. The training cycle involves various stages, including the assessment of the needs, the development of objectives, the design and development of the training program, implementation, and evaluation of performance [14]. All these stages must be properly planned and employed to ensure the success of training and the accomplishment of the objectives. The

use of digital platforms has enhanced the performance at each stage of the training cycle. Organizations have been able to enhance the management and governance of training processes by using technology, as it has improved monitoring and control [15]. Assessment of needs is a critical phase, which demands thorough research and analysis to determine the problem and need for training. Digital platforms for feedback collection and business analytics have enhanced the ability of organizations to effectively assess the needs and ensure better planning of training programs. Besides this, there is various software allowing convenient monitoring and control of training, ensuring that they are on the right track [16]. Also, the evaluation of performance has become more efficient through technology. Therefore, it can be noted that digitalization has majorly enhanced the training stages.

3- Hypothesis Development

The following hypotheses are developed based on the review of the literature.

Studies have shown that the use of the Zettelkasten has a significant impact on the thinking process of the learners. As per von Niederhäusern (2020) [17], the Zettelkasten method leads to an enhanced thinking process as the learners can reflect on the ideas and theoretical discourse. Through this practice, the individuals can memorize the concepts for the long term. Another study by Korolev & Lyalina (2021) [18] states that the use of the Zettelkasten method to make notes has a significant impact on the learners as this creative approach to making notes relies upon making references and relationships between different ideas. Due to this, the thought process of the learners is enhanced, leading to a stronger grasp of the lessons being given. Based on these findings from the literature review, the following hypothesis is framed.

H1: The use of Zettelkasten significantly enhances the performance of training programs in organizations.

The internal repetition system (spaced repetition method) has also been found to be effective in improving learning outcomes. According to Settles & Meeder (2016) [19], spaced repetition is a method that learners can use to revise the concepts after a specific interval that they had learned earlier. Due to this, the internal repetition system enables the learners to learn ideas and concepts with breaks until these concepts become a part of their long-term memory. This has the advantage that the learners do not get bored by learning a concept repetitively due to the spacing between the lessons. Internal repetition has also been observed to help students learn new ideas and concepts. For example, learning a new language can be conducted with higher efficiency using spaced repetition [20]. Based on these findings, the following hypothesis is formulated.

H2: The use of an internal repetition system has high effectiveness in enabling the learners to upgrade their skills and abilities.

Digital learning has gained significant boost since the pandemic of Covid-19 [21]. However, the complete digitalization of the training cycle has not been accomplished on a large scale. Researchers have found that the use of full-cycle training on a digital platform can enhance the learning outcome as it is able to provide a more personalized experience to the learners [22]. Besides this, through a digital model of training, planning and evaluation of the learning process are enhanced, which leads to a better experience for the learners. Hence, based on this, the following hypothesis is made.

H3: Digital learning programs can provide learners with a more convenient and enhanced learning experience.

The use of the Zettelkasten approach has been increasing as scholars have found its significant impact on the learning process. Amiri et al. (2017) [10] present that the Zettelkasten approach can be used with digital learning models to enhance learning. Psychology has shown the high performance of learners when they can connect ideas and gain logical knowledge. Combining the Zettelkasten approach with the digital model has high effectiveness as it reduces the complexity of making notes based on the Zettelkasten approach. Similarly, internal repetition systems have enhanced the learners' experience and performance [23]. Its combination with the digital models of training can optimize the spacing between the lessons to bring out the best outcomes. Hence, the following hypothesis is framed.

H4: Full-cycle training combining the Zettelkasten and interval repetition system can effectively enhance the learning experience and the effectiveness of the training courses for the students.

4- Materials and Methods

4-1- Research Design

An experimental design similar to the assumed approach is considered, which is one the important types of research design normally used in quantitative studies to acquire data/information to systematically elucidate a phenomenon, situation, or population [24, 25]. Moreover, experimental design is significant in addressing the answers associated with "what," "where," "when," and "how" queries linked to the problem statement rather than "why" questions by examining the phenomena in practice. Based on the objective of this study, a survey strategy is applied to collect data from the

participants, as this strategy is convenient for the researcher and economical to collect a large amount of data in a short duration. With the help of experimental design, the impact of Zettelkasten and the interval repetition system is evaluated on the learning and development of learners as per their needs. The research will use a comparative assessment of two groups of students to test the model effectiveness and validity.

4-2- Research Approach

This research has considered using a quantitative approach emphasizing mathematical, numerical, objective measurement and statistical analysis of the data collected using questionnaires, polls, and surveys or by managing pre-existing stats-centric data using computational techniques. According to Taguchi (2018) [26] and Biereenu-Nnabugwu (2019) [27], quantitative approach other than approaches (that depend on numerical and non-statistical data analysis) is suitable for this study to achieve the key objective. This approach considers statistical evidence which is needed to assess the impact of Zettelkasten and the interval repetition system on the learning of people. The use of these concepts can be further elucidated through quantitative methods and techniques, unlike the qualitative approach.

4-3- Research Strategy

A survey strategy is applied in this study, as highlighted earlier. This strategy is useful for quantitatively collecting data from the research participants using a questionnaire. The overall process comprises recruiting research participants, data collection, interpretation, and analysis [28]. A metacognitive awareness survey was used to test the perceived understanding and performance of the students using the digital full-cycle training model. The use of a survey strategy is important in assessing the effectiveness of the digital model of training based on Zettelkasten and the interval repetition system.

4-4- Target Population and Sample Size

The population of the study includes the students who took part in the experiment where Zettelkasten and the interval repetition system are applied. These students were trained using Zettelkasten and the interval repetition system in a digital full-cycle training model. In terms of sampling strategy, a non-probability and convenient sampling strategy was used, under which only accessible and available students were contacted to participate in the study. The sample size for this study was 40 (20 students in each group).

4-5- Data Collection

In relation to the assumed research approach, a first-hand primary data source is used to collect data from the respondents, as this type of source depends mainly on collecting new, updated, recent, and unexplored data about a topic or subject, parallel to the secondary source where molded, transformed, published and outdated data is used for the research [29]. Hence, using a survey strategy, the data are collectible to accomplish the objectives. Regarding the overall process of data collection, the study considers the 5-Likert scale to assess the responses of the participants and to measure the impact of Zettelkasten and the interval repetition system on students' learning and skill development. An online questionnaire survey was preferred to collect the data as it is inexpensive and less time-consuming to collect a large sample of data. Two groups of students who give the assessment will fill out the survey for data collection.

4-6- Data Analysis

In terms of data analysis techniques, descriptive statistics were applied to present the demographic analysis of the research population, along with correlation and regression analysis and statistical tests. Additionally, the descriptive analysis was useful in quantitatively describing or summarizing the features from the data collected. The correlation analysis was useful in assessing the link between the variables (i.e., Zettelkasten and the interval repetition system and impact on student learning and development), whereas regression analysis was performed to determine the link between dependent and independent variables.

4-7- Ethical Considerations

The research considered important ethical rules and principles when collecting the data from the participants. For example, the researchers ensured that the private information of the participants would not be disclosed publicly to ensure privacy and safety. The questionnaire sent to the participants excluded personal or professional questions that may harm the interests of their associated organization or somehow increase trouble for them. Moreover, the details of the research objectives, the process of data collection, and instruments used for collecting data were all communicated both verbally and electronically to the participants so that they were aware of the research and its process. The participants were given the right to withdraw from the study without informing the researchers. The data were collected in their free time and with their approval.

Figure 1 shows the flow of this research.

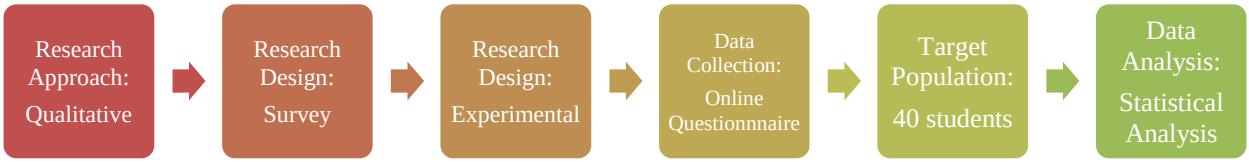

Figure 1. Flowchart of the research

5- Results and Discussion

5-1- Introduction

This section presents the development of the Full-Cycle Training for the students with the integration of Zettelkasten and the interval repetition system. The model is then tested to determine its effectiveness for appropriate training and learning of the students via two assessments; achievement assessment and metacognitive awareness survey. The achievement assessment assessed the effectiveness and validity of the model for enhancing the effectiveness of the students learning and training for various lessons, while the metacognitive awareness survey investigates the perceived understanding and performance of the students about the effectiveness of the digital full-cycle training model.

5-2- Proposed Model Based on the Integration of Zettelkasten and an Interval Repetition System

The Zettelkasten technique, separately, can be visualized in Figure 2.

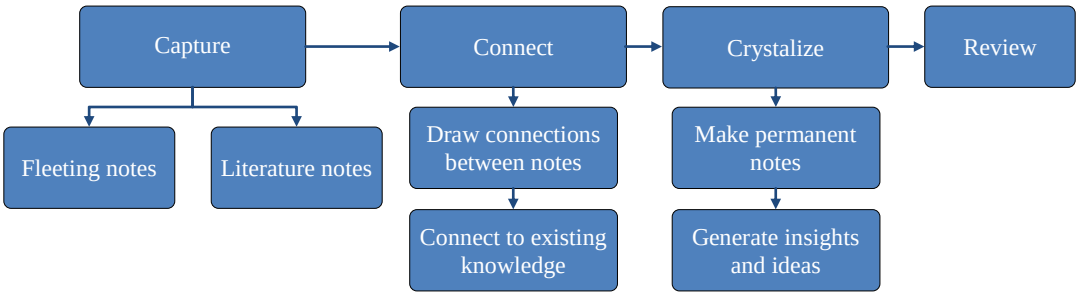

Figure 2. Learning and training model based on the Zettelkasten technique

By integrating the interval repetition system in the above technique in the aforementioned model for student learning and training, the review stage is divided into several reviews that will be conducted after prespecified intervals as shown in Figure 2. The mentioned intervals (in hours and days) can be changed according to the learning and training plan for the students. The rationale for integrating the interval repetition system with the Zettelkasten technique is based on the fact that even though the Zettelkasten technique offers a systematic way of making notes that can enable the students to keep all the essentials organized and sorted in one place. Howbeit, the technique does not offer guidance into how the review of the information shall take place to ensure that the learning is effectively retained in the memory to combat the effect of the forgetting curve that suggests that the information in the mind is lost over time as the time passes demonstrating memory retention tends to decline. Thus, the integration of the interval repetition system in the Zettelkasten technique will enable the students to make well-organized notes and then review the information over various intervals to permanently store the information in the brain.

In the context of digital full-cycle training, the students can use the model for making notes of their learnings and takeaways and then establish proper intervals for the review of the information to retain the knowledge and insights and internalize them over time. The model can be effectively followed via various digital tools. Nonetheless, Obsidian is one of the most effective note-taking platforms that can be used by students for storing and sorting their information.

5-3- Model Effectiveness Assessment

The effectiveness of the proposed digital model of full-cycle training was assessed via an experiment involving two groups of students; the experimental group and the control group. An e-learning and training course based on Corporate Innovation Management was offered to all the students of both groups comprising various digital resources, including books, slides, etc. Both groups were asked to prepare their notes, review major information and internalize the course content for an upcoming test that was to be conducted after two weeks. The experimental group was trained to use the

Obsidian platform to follow the full-cycle training model based on Zettelkasten and the interval repetition system in learning the digital training course. The students in the experimental group were asked to follow the steps in the proposed model: capture, connect, crystallize, and then review at different intervals. They had to make notes and organize information using the Zettelkasten approach by connecting various information pieces (lecture notes, book chapters, etc.) and specify three intervals for their learning and review. However, the students in the control group were not given any such information or training session to use the model. Rather, they were supposed to prepare for the assessment using conventional approaches of notes-making and information review. The control group was asked to only review information one time in one day after completing their course.

The instrument for the experiment was a *Digital Achievement Assessment* that comprised various questions, activities and cases based on the content of the Corporate Innovation Management digital training course. The overall score on the assessment was 50 marks. The students in the experimental group were closely monitored via frequent online communication. It was found that all the students had begun organizing the material into various repositories and folders based on the modules of the training course. Figure 3 shows an example of a description sent by a student in the experimental group. The figure shows that the students not only took notes but also organized the related information.

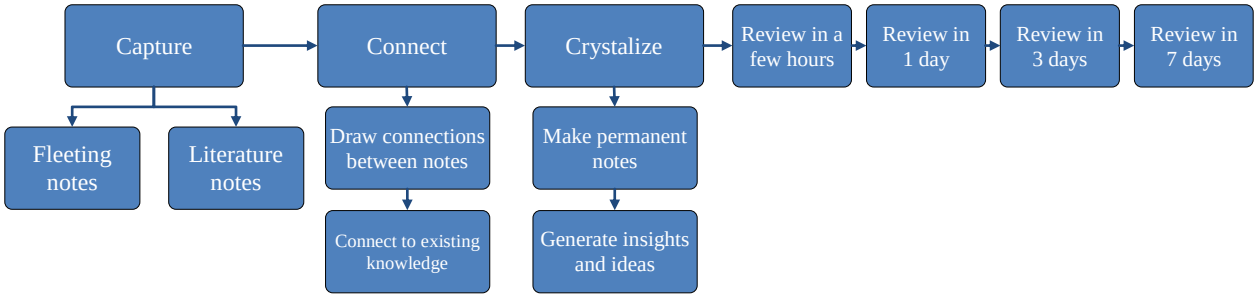

Figure 3. Digital model of full-cycle training based on the Zettelkasten and interval repetition system

Students using this platform could visualize the provided digital course. The visualization highlighted the topics and main ideas of each lecture, as well as the connections of the main ideas of each individual lecture with the other lectures of the course. The interactive visualization of the course is shown in Figures 4 to 6, which is an example by a student in the experimental group. Each blue dot represents a lecture topic, and each brown dot represents a subtopic of the lecture. The links of each subtopic with the others could be displayed when pointing at the point of the subtopic, as shown in Figure 4. Thus, the students could make sense of all the related content in a more organized manner.

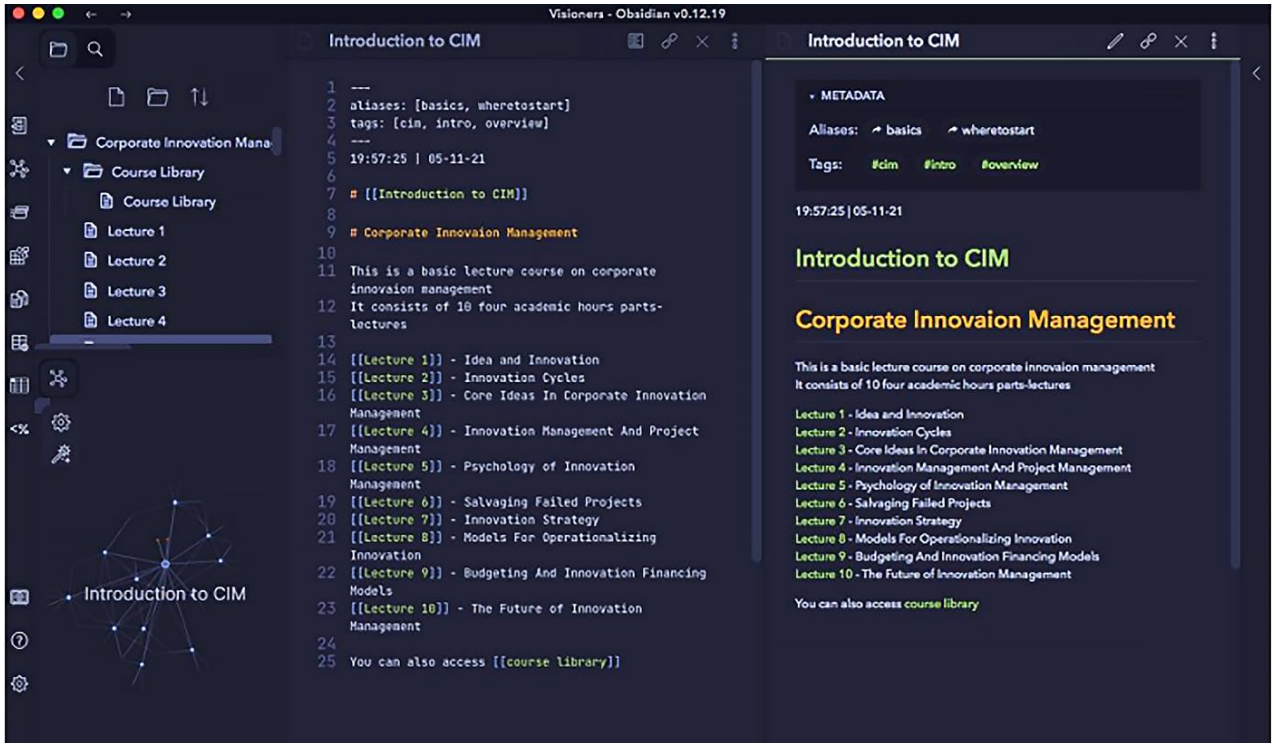

Figure 4. The material organization based on Zettelkasten via Obsidian

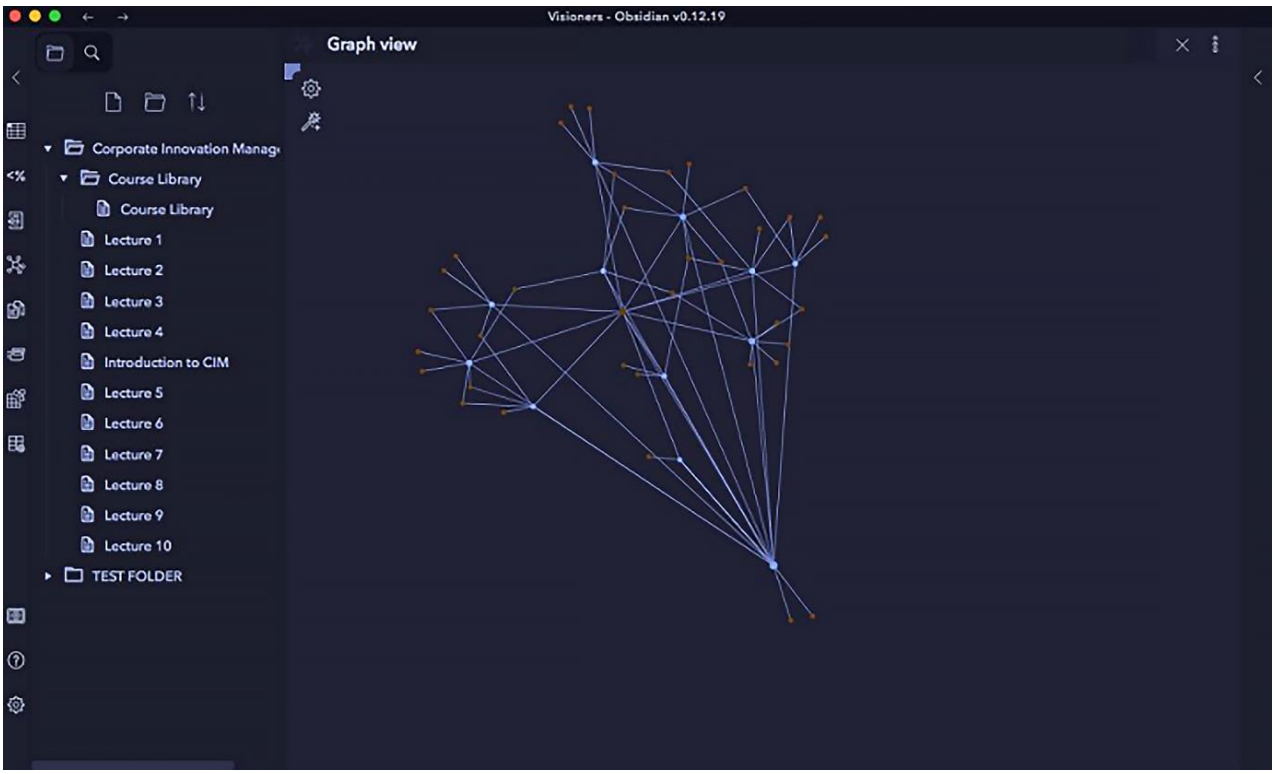

Figure 5. Links between the topics displayed by the platform

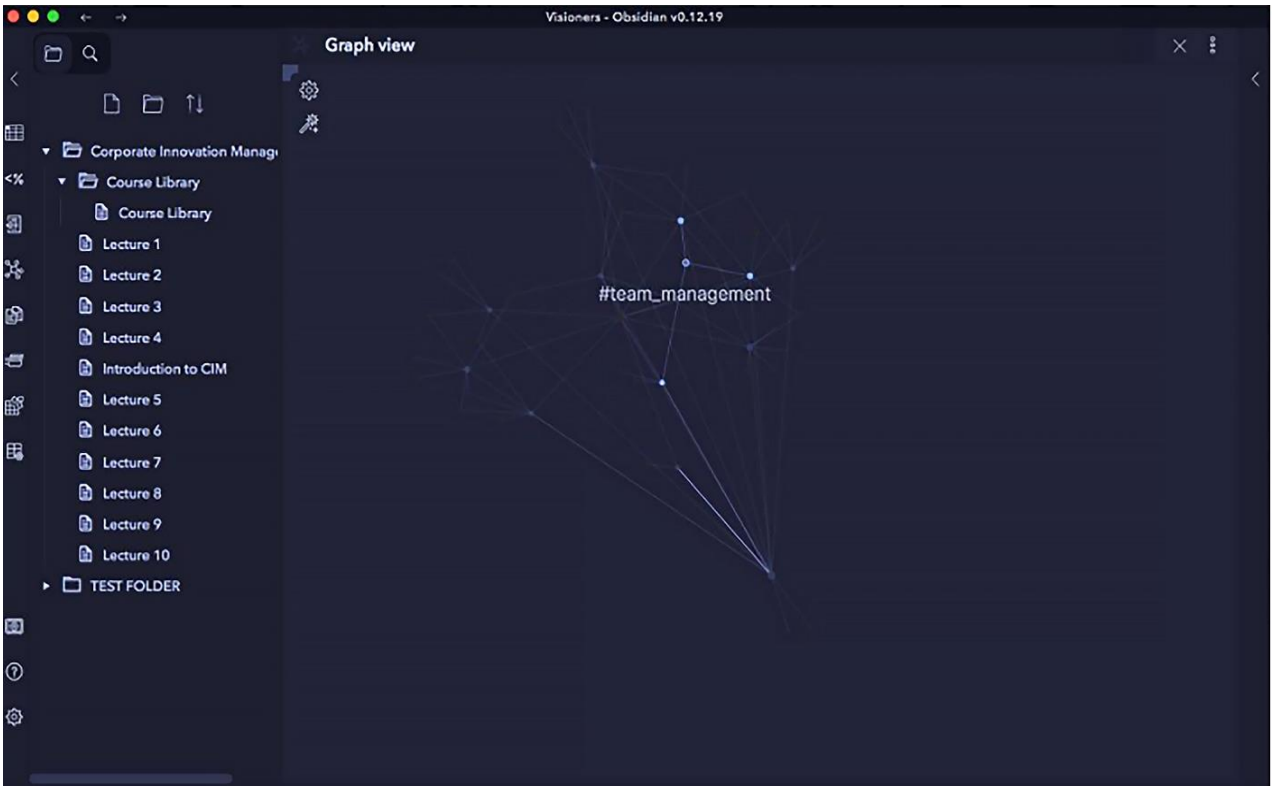

Figure 6. Links to the subtopics

Students in the experimental group effectively used their material organizing and note-taking for their learning and training. They organized notes and made permanent notes that can be used for the review of the information. After the organization of the information, the experimental group was given a timeline of four sessions for the review of the information after the interval of 1 day, then 3 days, then 5 days and then 7 days. The students used this timeline to review all the information noted in the permanent, literature and the fleeting notes. In opposition to this, the students in the control group followed their conventional practices of learning and only reviewed the information once.

The achievement assessment of both groups was conducted on the same day after two weeks of the provision of an e-learning and training course to the students (see Table 1). Table 2 presents the summary of the mean scores and the values of the standard deviation of the two groups. The mean score for the experimental group was found to be 40.2500 at a standard deviation of 4.21213, while the mean score for the control group was found to be 29.0500 at a standard deviation of 4.27323. Thus, the mean score of the experimental group was higher. The t-test was conducted to indicate the difference between the scores and the differential impact of the Digital Model of Full-Cycle Training on the students (as shown in Table 3). Since the results are found to be significant at a 100 per cent confidence level (p-value = 0.000) it shows that equal variances are not assumed and the value of the second column is to be considered. The mean difference was found to be 11.200 at a degree of freedom of 37.992.

Table 1. The case processing summary

Groups	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Experimental Group	20	100.0%	0	0.0%	20	100.0%
Control Group	20	100.0%	0	0.0%	20	100.0%

Table 2. Mean values of the effectiveness assessment

Report		
	Experimental Group	Control Group
Mean	40.2500	29.0500
Std. Deviation	4.21213	4.27323

Table 3. Independent t-test results of the effectiveness assessment

Independent Samples Test					
	Mean Difference	Std. Error Difference	t	df	Sig. (2-tailed)
Equal variances assumed	11.200	1.342	8.348	38.000	.000
Equal variances not assumed	11.200	1.342	8.348	37.992	.000

Hartley test for equal variance: F = 1.029, Sig. = 0.4746

Summarizing the results, it is found that the students who incorporated the Digital Model of Full-Cycle Training based on the Zettelkasten and interval repetition system in their learning and preparation of the provided digital course reported statistically significantly higher test scores (40.25 ± 4.21) than the students who used conventional practices without any notes taking and review after proper intervals (29.05 ± 4.27), t (37.992) = 11.2, p = 0.000.

The results of the assessment revealed that the students who used a combined model of Zettelkasten and interval repetition system in their training performed significantly better than the students who used conventional practices. Thus, the Digital Model of Full-Cycle Training actually contributed to better training, preparation and better information retention by the experimental group in the study.

5-4- Metacognitive Awareness Survey

The second phase of the assessment included a metacognitive awareness survey that was adapted from O'Neil Jr. & Abedi's (1996) [30] metacognitive awareness survey inventory. The assessment was comprised of 20 items and the students had to record their responses against a four-point Likert scale (ranging from "Not at all" at 1 to "Very much so" at 4) to demonstrate their level of agreement with the given statement based on their learning experience with the provided e-learning and digital training course. Tables 4 and 5 show the survey results for both groups in terms of descriptive statistics.

Table 4. Metacognitive awareness survey of the experimental group

Items	Min	Max	Mean	SD
I believe that I was well aware of my thinking when doing the test	2.00	5.00	3.9831	0.19765
I comprehensively understood the meaning of the assessment questions before attempting to answer them	2.00	5.00	3.0831	0.13657
I started the test by discovering the main themes and ideas in the given set of questions.	2.00	5.00	3.6751	1.91765
I could understand the major ideas and objectives of the test questions before answering them.	2.00	5.00	3.0011	0.75961
I knew different information and ideas that could be used to answer the questions	1.00	5.00	3.2457	0.12365
I believe that I had a strong conceptual understating of the training courses already	2.00	5.00	3.5418	0.12368
I found questions very easy as I had sufficient information in my brain to answer them	2.00	5.00	3.9831	0.12797
I used various alternatives to answer the questions	3.00	5.00	3.0091	1.24569
I could consciously focus my attention only on the most vital and important information when answering the questions	1.00	5.00	3.7863	0.24569
My pace matched the length of the paper. I was available to complete it before the time.	1.00	5.00	3.5863	0.15363
I remembered everything asked during the assessment	2.00	5.00	3.3952	0.72578
I believe I understood well what information had to be included in the answer and how to formulate the answers	1.00	5.00	3.2681	0.32456
I felt aware of my strengths and knowledge when attempting the assessment	2.00	5.00	3.0871	0.39671
I could effectively identify and report the most accurate and relevant information when answering the questions	2.00	5.00	3.7824	0.82645
I could fully comprehend the assessment	2.00	5.00	3.5926	1.14637
I believe that I could have a good judgment about the assessment	2.00	5.00	3.6982	0.28673
I could connect different information pieces when answering the questions	2.00	5.00	3.2984	0.73649
I did not have much trouble understanding the questions	2.00	5.00	3.3927	0.16823
I felt satisfied with my level of comprehension	2.00	5.00	3.4541	0.49376
My test preparation contributed well to my assessment performance	1.00	5.00	3.0246	0.26793

Table 5. Metacognitive awareness survey of the control group

Items	Min	Max	Mean	SD
I believe that I was well aware of my thinking when doing the test	1.00	2.00	2.3697	0.45976
I comprehensively understood the meaning of the assessment questions before attempting to answer them	1.00	3.00	2.3037	1.07922
I started the test by discovering the main themes and ideas in the given set of questions.	1.00	3.00	2.8692	0.65223
I could understand the major ideas and objectives of the test questions before answering them.	1.00	3.00	2.8624	1.44988
I knew different information and ideas that could be used to answer the questions	1.00	3.00	2.4781	1.63134
I believe that I had a strong conceptual understating of the training courses already	1.00	4.00	2.3892	0.30229
I found questions very easy as I had sufficient information in my brain to answer them	1.00	3.00	2.4897	1.25733
I used various alternatives to answer the questions	1.00	3.00	2.4381	0.25145
I could consciously focus my attention only on the most vital and important information when answering the questions	1.00	3.00	2.8564	0.79555
My pace matched the length of the paper. I was available to complete it before the time.	1.00	4.00	2.9001	0.54033
I remembered everything asked during the assessment	1.00	4.00	2.8634	0.71509
I believe I understood well what information had to be included in the answer and how to formulate the answers	1.00	4.00	2.3469	0.18316
I felt aware of my strengths and knowledge when attempting the assessment	1.00	4.00	2.3147	0.23678
I could effectively identify and report the most accurate and relevant information when answering the questions	1.00	3.00	2.2458	0.80020
I could fully comprehend the assessment	1.00	4.00	2.5697	0.79125
I believe that I could have a good judgment about the assessment	1.00	4.00	2.3465	0.49706
I could connect different information pieces when answering the questions	1.00	4.00	2.3259	0.38791
I did not have much trouble understanding the questions	1.00	4.00	2.7156	0.94367
I felt satisfied with my level of comprehension	1.00	4.00	2.4638	0.14063
My test preparation contributed well to my assessment performance	1.00	4.00	2.4141	0.34029

As demonstrated by the results of Table 5, for all the items, the value of the standard deviation is lower than the value of the means, which shows that the data points are located closer to the mean of the data instead of being scattered. This implies that the students in the experimental group provide consistent responses to the provided items in the metacognitive awareness survey. For the items, the value of the mean is greater than 3.0, which demonstrates the skewness of the data to the right side of the scale. This means that the students marked higher rating points ("Moderately

so" at 3 and "Very much so" at 4). This indicates that the students in the experimental group demonstrated a high level of agreement with the provided items, showing their high awareness and understanding of the training material.

Table 6 presents the results of the survey of the control group. The responses are found to be consistent and free from significant variances owing to the lower standard deviation values than those of the arithmetic mean values. In contrast to the results of the experimental group, the results of the metacognitive awareness survey of the control group revealed lower mean values for the responses that are between 2.3 and 2.7, which show the skewness of the data on the left side of the scale used ("Somewhat" at 2 and "Moderately so" at 3). Thus, the students in the control group demonstrated a lower understanding and awareness of their learning experience than the students in the experimental group.

Table 6. Mean values of the metacognitive awareness survey

Report		
	Experimental Group	**Control Group**
Mean	3.1500	2.9000
Std. Deviation	0.2000	0.2700

The value of the standard deviation and means for both groups of students are presented in Table 6. The mean value of the survey of the experimental group was found to be 3.15 at a standard deviation value of 0.37, and the mean value of the control group was found to be 2.9 at a standard deviation value of 0.27 (Table 6). The results of the t-test analysis showed that a significant difference exists in the performances of the two groups, as the students who incorporated the Digital Model of Full-Cycle Training based on the Zettelkasten and interval repetition system in their learning and preparation of the provided digital course reported a significantly higher understanding and awareness of their learning (3.15 ± 0.20) than the students who used conventional practices without any notes taking and review after proper intervals (2.9 ± 0.27), $t\,(35.026) = 0.25$, $p > 0.05$ (Table 7).

Table 7. Independent t-test results of the metacognitive awareness survey

Independent Samples Test					
	Mean Difference	**Std. Error Difference**	**t**	**df**	**Sig. (2-tailed)**
Equal variances assumed	0.250	0.075	3.327	38.000	0.002
Equal variances not assumed	0.250	0.075	3.327	35.026	0.002

Hartley test for equal variance: F = 1.029, Sig. = 0.4746

6- Discussion of the Findings

All in all, on the basis of the results, the hypothesis of the study was found to be true, as it is proposed by this study that the proposed digital model of full-cycle training based on the Zettelkasten and interval repetition system can effectively enhance the learning experience and the effectiveness of the training courses for the students. The proposed digital model is termed a "full-cycle training (or learning)" model because this new model, with the integration of two techniques, the Zettelkasten and the interval repetition system, facilitates the management of a full cycle of student learning, from receiving information, taking notes, and organizing information to the retention and storage of the information in the long-term memory of the student. The higher assessment score of the experimental groups showed that the use of organized training with the integration of Zettelkasten that enabled the students to draw links between the information and knowledge resulted in an enhanced learning experience, contributing to better understanding. This finding of the study is found to be in line with the assertions of Ratcliffe (2021) [5]; the use of Zettelkasten can enhance the students' learning and training outcomes due to their ability to internalize information and establish a better conceptual understanding rather than cramming the knowledge.

In the context of a digital learning environment, given that attention is a cognitive process that involves the selective concentration of resources on a given item of information to the exclusion of other perceivable information, attention can be considered in terms of limited processing resources [31]. It is also suggested by Hartley & Davies that the number of notes taken declines over the course of a lecture, consistent with "attention" decline after the first 10–15 minutes of a lecture (as cited by Felder & Brent (2016) [32]). In this regard, the use of Zettelkasten ensures that the attention of the students is not distracted and that students are to actively record their learning using the Zettelkasten. Furthermore, the students in the study can also connect many streams of knowledge and thinking [9]. All in all, it can be deduced that with the integration of Zettelkasten in the learning and training model of the students, they could make it easier for themselves to expand their knowledge, organize the information, and make new connections among ideas.

Howbeit, it is worth noting that, along with attention, information and knowledge retention is yet another problem for the students. Even if the students can give much attention to the knowledge while learning, it does not guarantee the

retention of the knowledge in the long term. Thus, Zettelkasten alone cannot be deemed sufficient for the students for the long-term retention of knowledge. This conclusion is supported by the findings of Maddox & Hoole (1975) [33], who suggested that note-taking is not necessarily indicative of knowledge retention in the long run. Thus, the student may be able to grasp the knowledge and the conceptual understanding of a certain phenomenon. However, to retain the knowledge permanently in the brain, the student must make additional efforts to review the knowledge. As per Tabibian et al. (2019) [34], the retention of knowledge in the long term is based on three factors; the number of times the review of the information is conducted, the length of duration between the reviews, and the length of time since the last review of the information was done.

This is where the role of the interval repetition system comes into play. Correspondingly, the integration of the interval repetition system with the Zettelkasten in the assessment boosted the retention of the information by the students, which was evident from the results of the assessment and survey. This finding is also found to be in line with the findings of the extant literature that suggest that the repetition of the information helps in better retention, making the information unforgettable [12, 35, 36]. Thus, the use of the interval repetition system actually boosted the retention of the students, as the students who only reviewed the training material a day after the training completion performed lower on both the effectiveness assessment and the metacognitive awareness survey than the students who reviewed the assessment four times with intervals of 1 day, then 3 days, then 5 days, and then 7 days.

As per Brown et al. (2014) [37], every time people receive and review certain information, they remind their brain that it is important, and they resume the process of 'consolidation that connects different pieces of information, makes sense of the information, and then stores it in the long-term memory of the brain. In this regard, the greater the perceived difficulty in learning and remembering information, the greater the results can be achieved by dividing the effort of the learner to review and remember the information, which improves the information. These assertions specify the connections between the use of Zettelkasten for making sense of the information via notes taking and connecting information and the use of the interval repetition system for retaining information in the long-term memory via information review at multiple instances. Thus, such literature postulates rationalizing the use of the new digital model that manages the full cycle of learning from taking notes and information organization to the retention of the information. All in all, the proposed digital model of full-cycle training was found to be highly effective for the learning and training of the students.

7- Conclusions

7-1- Findings of the Study

The paper proposed a new digital model that integrates the use of Zettelkasten and the interval repetition system for full-cycle training and learning by the students. This study is first to suggest the integration of Zettelkasten and the interval repetition system into one learning model for the students. The two techniques have been discussed separately in the context of learning in the previous literature. The paper emphasizes the idea that the combined use of the two techniques would be more effective in enhancing the conceptual understanding, performance, and learning experience of the students in the provision of the training course. The use of Zettelkasten can facilitate the management of the student's attention during learning via active notes tasking and making sense of the information by organizing the knowledge and drawing links between different pieces of information. This would enable the students to develop a better conceptual understanding of their training course information. Concurrently, the use of the interval repetition system facilitates the long-term retention of information via information review at multiple intervals. This will ensure that the information being delivered via the training course is retained in the mind of the student for a lifetime rather than for the time being. Thus, the study recommends an integrated model based on Zettelkasten and the interval repetition system for improving the student's learning experience and performance.

7-2- Study Contributions and Limitations

The study proposes a new model to increase the overall effectiveness of students' learning and training. The article redounds to the extant literature with theoretical implications in terms of the effectiveness of the interval system, or note tasking, for learning and training. Additionally, the article offers practical implications in terms of a practical model that can be incorporated by teachers to improve the learning effectiveness of their students. This article has some limitations as well that must be acknowledged. The article does not disclose many nuances of the work or study the model's application in a different context. Rather, the researcher has just investigated the application of the model in the context of student training only.

7-3- Recommendations for Future Research

Taking into account the aforementioned limitations of the study, a more detailed consideration will be the subject of further research and work. Of particular interest is the investigation into the role of this model in facilitating the students to study and manage their learning in an autonomous and independent manner without much involvement of the teacher.

Also, the study has only investigated and discussed the viability of the model for a "management" course. In this regard, the authors of the work recommend that such a methodology be significantly improved for teaching courses other than the direction of "management." Thus, a broader scope can be incorporated for future research investigating the viability of the model for different disciplines.

8- Declarations

8-1- Author Contributions

Conceptualization, M.E.K.; methodology, M.E.K.; validation, S.V.F.; formal analysis, R.A.A.; investigation, T.A.B. and S.S.D.; resources, L.D.S.; data curation, V.V.P.; writing—original draft preparation, M.F.H.; writing—review and editing, G.T.M.; visualization, O.A.G.; supervision, M.E.K.; project administration, M.E.K. All authors have read and agreed to the published version of the manuscript.

8-2- Data Availability Statement

The data presented in this study are available in the article.

8-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8-4- Institutional Review Board Statement

Not applicable.

8-5- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

8-6- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

Scale: SD = Strongly Disagree D = Disagree N = Neutral A = Agree SA = Strongly Agree

Items	SD	D	N	A	SA
I believe that I was well aware of my thinking when doing the test	1	2	3	4	5
I comprehensively understood the meaning of the assessment questions before attempting to answer them	1	2	3	4	5
I started the test by discovering the main themes and ideas in the given set of questions.	1	2	3	4	5
I could understand the major ideas and objectives of the test questions before answering them.	1	2	3	4	5
I knew different information and ideas that could be used to answer the questions	1	2	3	4	5
I believe that I had a strong conceptual understating of the training courses already	1	2	3	4	5
I found questions very easy as I had sufficient information in my brain to answer them	1	2	3	4	5
I used various alternatives to answer the questions	1	2	3	4	5
I could consciously focus my attention only on the most vital and important information when answering the questions	1	2	3	4	5
My pace matched the length of the paper. I was available to complete it before the time.	1	2	3	4	5
I remembered everything asked during the assessment	1	2	3	4	5
I believe I understood well what information had to be included in the answer and how to formulate the answers	1	2	3	4	5
I felt aware of my strengths and knowledge when attempting the assessment	1	2	3	4	5
I could effectively identify and report the most accurate and relevant information when answering the questions	1	2	3	4	5
I could fully comprehend the assessment	1	2	3	4	5
I believe that I could have a good judgment about the assessment	1	2	3	4	5
I could connect different information pieces when answering the questions	1	2	3	4	5
I did not have much trouble understanding the questions	1	2	3	4	5
I felt satisfied with my level of comprehension	1	2	3	4	5
My test preparation contributed well to my assessment performance	1	2	3	4	5