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Conference Paper

Improving Student Outcomes Using Cognitive Load Theory-Based Multiple-Assessments throughout Online Learning of the Musculoskeletal Block During the COVID-19 Pandemic

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ABSTRACT

Since its first emergence in China, the global spread of COVID-19 had reached 269.721.683 cases in over 200 countries in December 2021. The rapid spread of this virus had urged WHO and governments to establish policies on physical distancing. Restriction of offline learning activities in Indonesia forced the educational institution to rapidly adapt. As consequence, we had to change all learning and assessment processes into online forms. We found many challenges in the implementation, particularly in the assessment processes. Therefore, in consideration of Cognitive Load Theory, we decided to intervene in these problems by implementing multiple assessment strategies in Musculoskeletal System Course, for 2020 batch students. We compared the results of the 2020 cohort with the results of the 2019 cohort in the Musculoskeletal System using the Mann-Whitney test (SPSS version 24). There were 256 students (2020 cohort) who participated in this System in comparison to 318 students (2019 cohort). Statistical analysis showed that there was a significant difference between the outcomes of the 2020 cohort that experienced multiple assessments before final examination in comparison to 2019 cohort who only experienced single-end examination (p -value <0.000). Mean outcomes of 2020 cohort (334.34) where significantly higher compared to 2019 cohort (240.96). Our study had shown that students' outcome during online learning due to COVID-19 pandemic can be improved by chunking the volume of learning materials into several parts. This method was in line with Cognitive Load Theory and gave possibility for students to organize their learning as well as to get multiple feedback for their improvement.

Keywords: Cognitive load theory, multiple assessment, musculoskeletal system, COVID-19 impact

Introduction

Since its emergence in China in December 2019, the global spread of COVID-19 has reached 60.234.023 cases in over 200 countries (John Hopkins University, 2021). The rapid spread of this virus has urged WHO and governments to establish policies on physical distancing. Worldwide, universities are temporarily closed to prevent mass gatherings (Wilcha, 2020). Face-to-face

learning activities were either postponed or modified into other forms of learning (Dost et al., 2020).

To be able to ensure the continuation of academic processes, alternative learning strategies have to be adopted. Indonesia's first COVID-19 case was reported in March 2020 and till now it has reached 511.836 cases with 16.225 death cases (John Hopkins University, 2021). Responding to this global pandemic, the Indonesian Government takes several actions to restrain the spread, including temporary restrictions toward face-to-face educational activities (Republik Indonesia, 2021).

Medical education was severely affected by this situation, with the suspension of both undergraduate and clerkship learning processes. All clinical rotations are stopped since most required frequent patient contact, and therefore imposed the risk of exposing the student to the SARS-CoV-2 (Dost et al., 2020; Monaghan, 2020).

Restriction of offline learning activities in Indonesia was announced in the middle of the ongoing semester and it forced the educational institution to rapidly adapt, and it included Faculty of Medicine Universitas Hasanuddin. As consequence, we had to make an emergency plan to assure the learning process. All learning and assessment were done online. Learning strategies were changed into synchronous and asynchronous sessions. Fortunately, our faculty had implemented blended learning since 2017 and during the pandemic restriction, most of our blocks have already had recorded lectures, active learning modules, and quizzes. The comparison of learning activities, as well as assessment before and after restriction, is presented in Figure 1.

Before restriction due to pandemic COVID-19 = Blended Learning	After restriction due to pandemic COVID-19 = Online Learning

Learning Strategies

Before face to face session (online asynchronous)	Students must study the resources in Learning Management System (LMS) = lecture videos, formative quizzes, assignments	Before synchronous online session	Students must study the resources in Learning Management System (LMS) = lecture videos, formative quizzes, assignments
Face to face session (offline)	Small group discussion Problem based learning Laboratory practice	Synchronous online session	Online Small group discussion Online Problem based learning Online Laboratory practice Via Zoom

Assessment Strategies

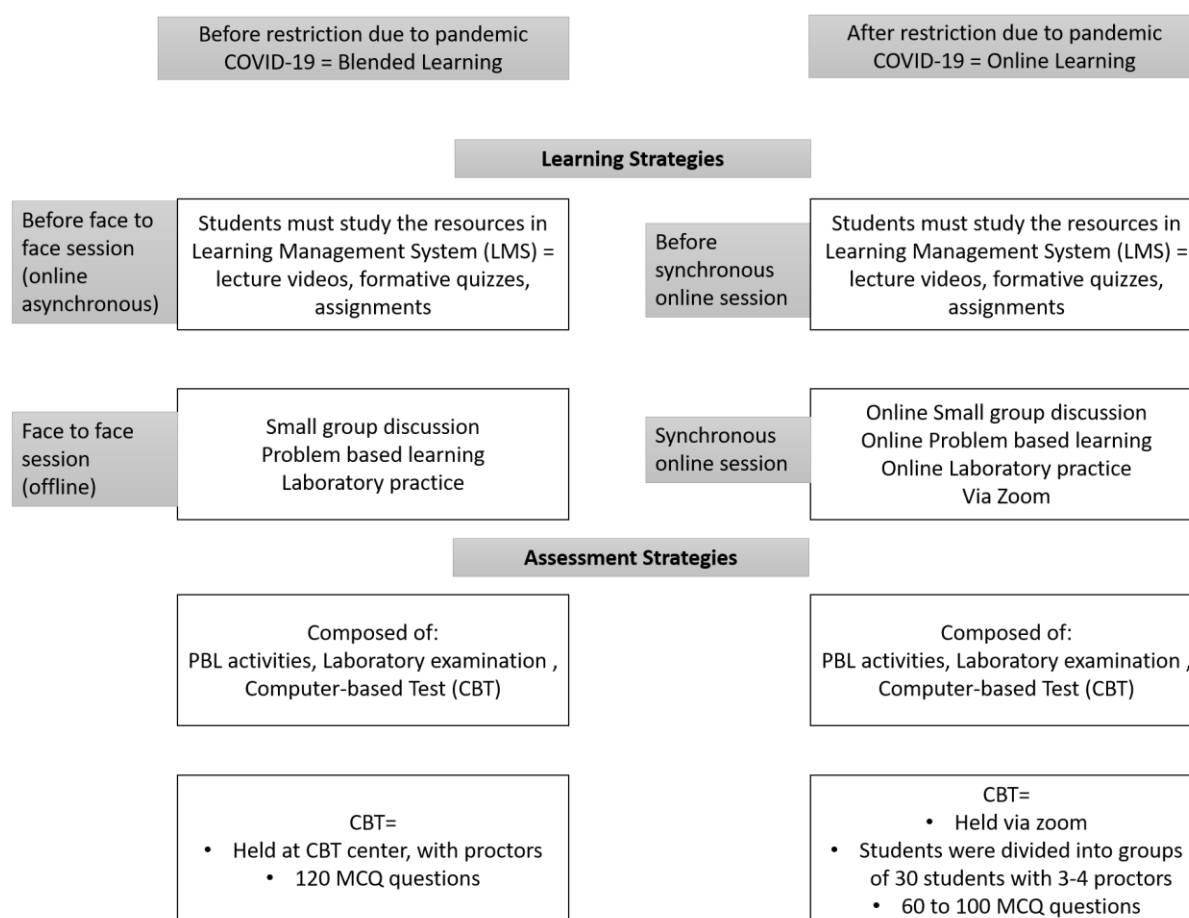| Composed of: PBL activities, Laboratory examination , Computer-based Test (CBT)	Composed of: PBL activities, Laboratory examination , Computer-based Test (CBT)
CBT= • Held at CBT center, with proctors • 120 MCQ questions	CBT= • Held via zoom • Students were divided into groups of 30 students with 3-4 proctors • 60 to 100 MCQ questions

Figure 1. The comparison of learning activities and assessment before and after restriction due to COVID-19 Pandemic

Online CBT had several challenges. Among them were how to prevent cheating, connectivity, and device compatibility issues (Wilcha, 2020). Several institutions have changed into open book examinations (Dost et al., 2020; Monaghan, 2020). However, although this examination is valued because it could reduce stress level of students, the questions had to be carefully designed (Dost et al., 2020; Monaghan, 2020). Open book examination is also considered unable to measure students cognitive competence adequately since students can access the resources (Sani et al., 2020). Therefore, we preferred to use proctored exams as one of our assessment methods.

However, we still found many challenges with this type of examination and had been implementing strategies to overcome them (Figure 2). Restriction of time in CBT had forced us to compromise on the total question numbers and reduced the questions to 60-100 questions for each CBT. The reduction of number of questions on CBT caused under sampling issues that can threaten the assessment validity. We also found that students grades were decrease compared to their academic achievement before offline restriction. This condition can be affected of many factors. Among them are sudden change from offline to totally online learning where learning can be distorted by many factors such as connectivity, isolation, less interaction, financial, and many more (Rajab et al., 2020; Tabatabai et al., 2020; Wilcha, 2020). Those problems can contribute to decrease of students understanding. Therefore, we decided to intervene these problems by implementing multiple assessment strategies where assessment materials were chunked into several parts. This strategy was based on Cognitive Load Theory which was introduced by John Sweller in 1988 (Young et al., 2014). This theory explains three cognitive load that can affect working memory, which are intrinsic load, extraneous load, and germaine load (Van Merriënboer & Sweller, 2010; Young et al., 2014). Intrinsic load is related to the amount of tasks that need to be performed, extraneous load is associated with aspects outside of the tasks, and germane load is related to learning processes in dealing with intrinsic load (Van Merriënboer & Sweller, 2010; Young et al., 2014). One strategy to increase working memory based on this theory is to decrease intrinsic load which can be done by chunking the learning material into several parts (Young et al., 2014).

Challenges in Online Proctored Examination and efforts to overcome

Cheating →
- Divided students into groups of thirty, 3-4 proctors each group
- 1 Laptop to work on the questions, 1 mobile device for supervision using Zoom
- ID card and room checked before CBT started
- Mirror placed in front of students
- Students had to be appeared in Zoom during examination
- Randomized questions and options

Connectivity and compatibility issues →
- Detailed explanation regarding requirements both for connection and gadgets used

Technical issues →
- Requirements that students had to appeared in Zoom caused time of CBT had to be limited into one hour maximum
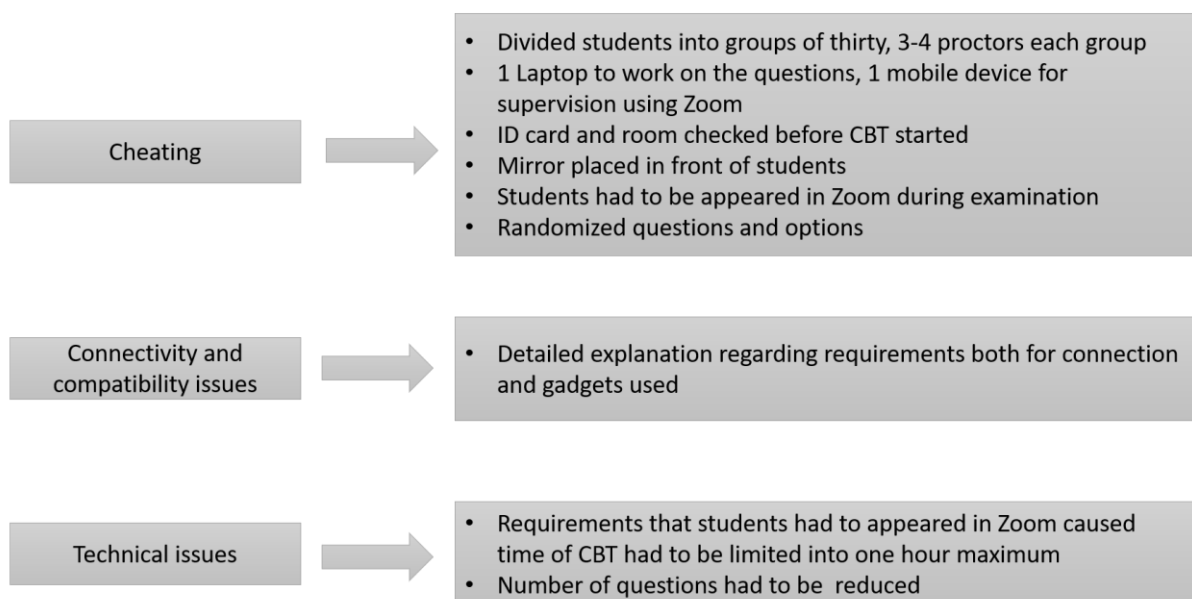- Number of questions had to be reduced

Figure 2. Challenges in online proctored examination and our efforts to overcome the challenges

Chunking the material that students need to learn will allow students to organize their learning better and therefor can improve their understanding (Seymour-Walsh et al., 2020). It also can provide information on student progress and feedback for further improvement (Guangul et al., 2020). This way, we could decrease students burden by distributing the assessment into several parts compared to study all materials in one assessment only. This intervention was also aimed to resolve under sampling problems because we could measure more with more questions allocated for each part of assessment.

Musculoskeletal System is the first subject in our third semester curriculum. It was a five-week block that presented integration of basic and clinical sciences of disorders in musculoskeletal system. Our complete curriculum map is presented in Figure 3. This study was done to evaluate the changing from single-end examination toward chunking the examination into several steps before final examination.

Semester 7	Tropical Medicine	Emergency and Traumatology	Community Medicine	
	CSL VI, Disaster Management, Scientific Writing			
Semester 6	Forensic & Medicolegal	Gastroenterohepatology	Life Cycle	
	CSL V, Character Building, Field Study			
Semester 5	Neurology	Psychiatry	Special Senses	
	Acupuncture, Pain Management, CSL IV			
Semester 4	Endocrine & Metabolism	Urogenital	Reproductive	
	Bahasa Indonesia (2 SKS), Bahasa Inggris (2 SKS), CSL III (3)			
Semester 3	**Muskuloskeletal**	Respiration	Cardiovascular	
	CSL II, Research Methodology, Religion			
Semester 2	Biomedicine 5	Basic Mechanism of Disease	Immunology and Hematology	
	CSL I, Public Health, Citizenship			
Semester 1	Biomedicine 1	Biomedicine 2	Biomedicine 3	Biomedicine 4
	Learning Skill, Phylosophy, Bioethic and Humaniora			

Figure 3. Curriculum map of Faculty of Medicine Universitas Hasanuddin. Musculoskeletal system is highlighted blue

Material and Methods

Musculoskeletal system in were programmed by third semester students. It involved three groups of subjects which is presented in Figure 4. Figure 4 also described the difference between single point CBT from previous year and the multiple assessment intervention.
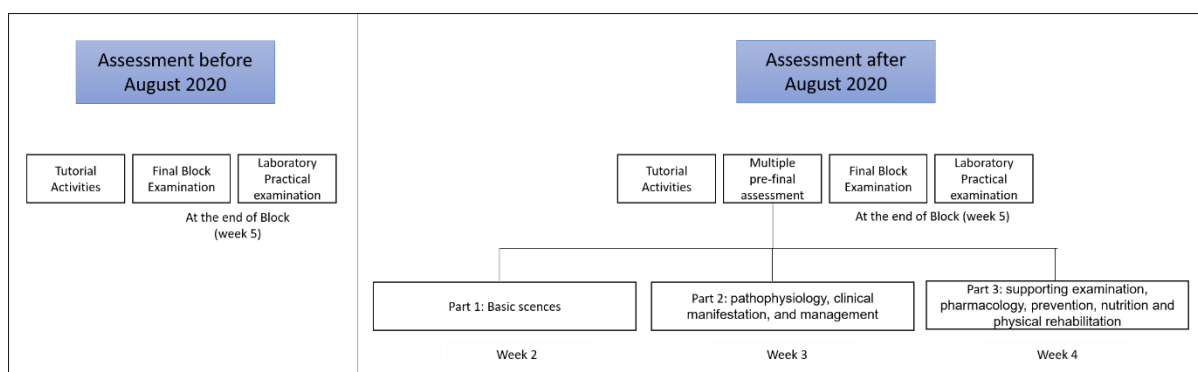

Figure 4. Comparison of assessment before and after august 2020 and description of three parts of subjects in Musculoskeletal System

The Musculoskeletal system assessment for 2020 cohort and 2019 cohort were similar which was combination of PBL, practical assessment and final examination. The proportion of each component is presented in Table 1.

Table 1. Proportion of assessment component for final grades of Musculoskeletal Block

Assessment Component	Proportion (2020)	Proportion 2019
PBL	10%	10%
Online Laboratory Assessment	5%	10%
Average of three parts of pre-final assessment	25%	
Final assessment	60%	80%

The questions used in the examination was chosen based on the blueprint and they are not re-used in the final examination to assure the validity of the assessment. The assessments were done using Moodle LMS platform where questions and their options were randomized. There was also time restriction based on the difficulty of each assessment.

The statistical analysis used to compare the results of 2020 cohort with results of 2019 cohort in Musculoskeletal Block was Mann Whitney test and was performed using SPSS version 24.

As additional analysis, we also compared students 2020 and 2019 cohort performance from Immuno-hematology block. This subject was the first subject in previous semester that implemented fully online strategy due to Covid-19 pandemic. This analysis was done to justify that improvement we obtained in Musculoskeletal Block was influenced by multiple assessment strategies and was not caused by the fully online strategies.

Results and Discussion

There were 256 students (2020 cohort) participated in this System in comparison to 318 students (2019 cohort) who took the subject last year. Twelve students were excluded due to absence in several examination for various reasons such as connectivity, electricity, and gadget issues.

We performed Saphiro Wilk test to see the normality of our data. Both data showed as not normally distributed. The data then was compared using Mann Whitney. The results were presented in Figure 5.
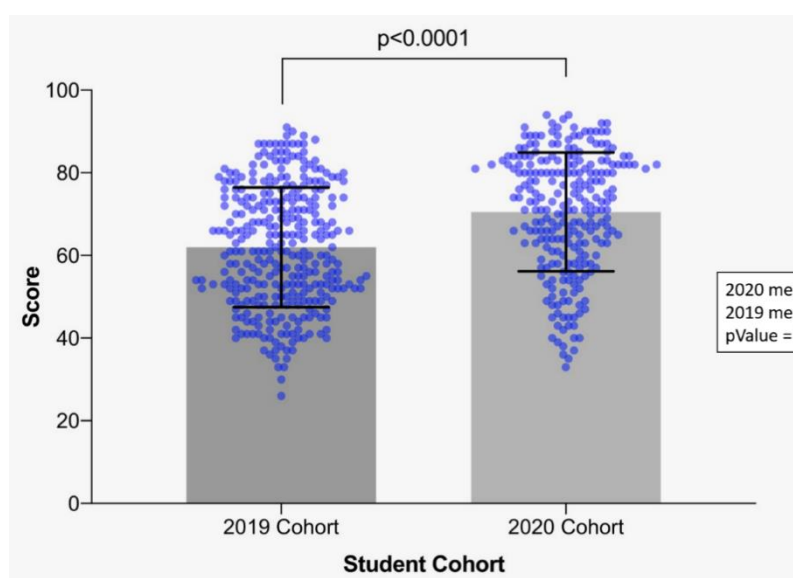
Figure 5. Comparison between musculoskeletal block outcome of the 2019 cohort (n=244 students) and the 2020 cohort (n=318 students). Figures show mean ± standard deviation, p<0.0001, Mann-Whitney test

Statistical analysis showed that there was significant difference between the outcomes of 2020 cohort that experienced multiple assessments before final examination in comparison to 2019 cohort who only experienced single-end examination. Mean outcomes of 2020 cohort where significantly higher compared to 2019 cohort.

Several weaknesses of online learning have been identified which include technical problems (such as connectivity and compatibility issues)(8), low interactivity and students' engagement (Wilcha, 2020). Rajab et al. (2020) also highlight other challenges which include issues on communication, assessment, technology tools, pandemic related stress, and technophobia. These challenges can contribute to decrease of students outcomes (Wilcha, 2020).

Our study showed that students with multiple assessment had significantly higher outcomes compared to students with only one assessment. This showed that even though students were studying fully online they still can manage to overcome the challenges of online learning by facilitating their learning with chunked assessment.

Experience on previous semester online learning strategies due to COVID-19 pandemic in our faculty also shown decrease in students' outcome. This study focused on our intervention regarding the assessment process where we have chosen to chunk students learning and by means we added several assessment steps before final block assessment. It suggests that chunking the material that students need to learn will decrease the learning burden and allow students to be better in organizing their learning. In the end, it can improve their understanding (Seymour-Walsh et al., 2020). It also provide feedback on students' progress which can facilitate students in identifying their weaknesses they need to improve further (Guangul et al., 2020).

Our finding was aligned to Cognitive Load Theory which points out that chunking the material can decrease intrinsic load. This decrease then can facilitate working memory to receive the information in smaller pieces before transfer the information to long term memory. This process than able to improve students' performance (Qiao et al., 2014; Van Merriënboer & Sweller, 2010; Young et al., 2014).

We maintain assessment validity by implementing blueprint in constructing the assessment questions. Questions in pre-final and final examinations were not the same. We also gave full effort in maintaining assessment integrity by implementing strict rules and procedures during online assessment including using 4 proctors for every 30 students, using Zoom as supervision media, and ensure students were working individually during the assessment.

Limitations

There are several limitations in this study. We only looked on the assessment side of online learning and have not explore more on the learning process and its influence in students' outcomes. We also have not investigated students' perspective regarding our intervention. And even though we have put lots of efforts in maintaining assessment integrity there still be possibility of academic misconduct during online assessment. One other limitation was that the learning strategies of 2020 cohort were very different with 2019 cohort and even though several studies had shown that online learning during COVID-19 pandemic tend to have lower students' outcome, there was still possibility that the significant difference can also be influenced by the different learning strategies. However, our additional analysis showed that students with fully online strategies had lower performance compared to blended learning strategies. Therefor we could justify that our intervention in chunking the material with multiple assessment strategies can enhance students' performance.

Conclusion

Our study had shown that students' outcome during online learning due to COVID-19 pandemic can be improved by chunking the volume of learning materials into several parts. This method was in line with Cognitive Load Theory and gave possibility for students to organize their learning as well as to get multiple feedback for their improvement. Further studies need to explore the influence of online learning in students' outcome as well as to gain students' perspective in this type of intervention. There should be also another study that explore the use of other aspects of cognitive load theory in promoting students' performance.

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