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The Implementation of ICT-Based Flipped Classroom for Linear Algebra Course

Himmatul Ulya
Universitas Muria Kudus, Indonesia

himmatul.ulya@umk.ac.id

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ABSTRACT

The flipped classroom learning in Linear Algebra learning could be applied as alternative learning that utilizes technology. Hence students involved in the learning and their learning autonomy would be fostered. This article analyzing the stages of Linear Algebra learning, the implementation of learning, and describing the students' learning outcomes. The subjects were the first semester students in the academic year of 2019/2020, of the Mathematics Education Study Program, Universitas Muria Kudus. The data collection technique consisted of test and non-test. The technique test was used to measure mathematics ability while the non-test technique was applied to measure the students' learning autonomies and learning observation. The applied data analysis consisted of a qualitative description. The findings described the stages of the Linear Algebra course. They consisted of designing the course, developing the content and learning media, uploading the learning material, using ICT for the learning, promoting the assessment, and providing feedback facilitation. The course was begin by providing a problem to be solved in a group. The material was uploaded in the e-learning platform. The students were facilitated to create groups. They were then allowed to find solutions stage via the internet accessed from their handphone/laptop. They were then asked to solve the problems on the given worksheet manually and utilizing the computer program. After discussing, they presented the results. The average of their mathematics ability reached a predicate of B while their learning autonomy was in the excellent criterion.

Keywords: *Flipped Classroom, Learning Outcomes, Linear Algebra Course*

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INTRODUCTION

Current era development cannot be separated from technological advancement. Information could be obtained quickly via technology (Muhasim, 2017). Fast information and communication technology development influences various human life aspects included the educational field (Lubis, 2016). One of the applied technologies in education is realized in learning. The technology development should be followed by learning quality improvement. The lecturer could improve the learning quality through integrating the Information and Communication Technology in the learning to improve the academic competences.

The use of technology in the *cyber-physical system* era learning should be considered to reach the learning objective. The achievement of the learning objective is an indicator of education success. As stated in the Regulation of the Research, Technology, and Higher Education Ministry (Permenristekdikti) Number 44, the Year 2015, about the national higher education standard, states that learning achievement is defined as the obtained ability through affective, cognitive, and psychomotor internalizations (Menristekdikti, 2015). It is since Indonesia requires a reliable human resource that does not only have cognitive competence but also strong characters to compete in the globalization era and ASEAN Economy Society. In this 4.0 era, intellectual human resource is required to solve problems in the future. Thus, mathematics problem-solving ability become a required ability for the students to make them able to solve the problems.

The linear algebra is one of the courses which could develop the mathematics problem-solving ability of the Mathematics Education Study Program students of Universitas Muria Kudus. It is due to mathematics problem-solving ability is the core of mathematics (Branca, 1980). Therefore, learning mathematics should also develop higher-mathematics thinking ability. They are such as understanding, reasoning, connecting, communicating, representing, thinking critically, thinking creatively, thinking analytically, having evaluative thought, thinking reflectively, thinking synthetically, and solving problems in mathematics (Sumarmo, 2013). Mathematics problem-solving is applicable meant not only to develop thinking ability but also to develop the students' basic ability in solving problems in daily lives (Pimta et al., 2009).

Linear Algebra is one of the courses in the Mathematics Education Study Program. It has 3 credits and it requires an appropriate method to reach the learning objectives. It is since the learning material of the course has theoretical and applicative natures. Thus, it could make the students bored and feeling uninvolved in learning due to lecturer-centered learning. When this condition sustains continuously, it could lead to the failures of the learning objective achievements. As stated in the Article 11, the Regulation of the Education, Research, and Higher Education Ministry (Permenristekdikti), Number 44, the Year 2015, that the learning characteristics of hider education are interactive, holistic, integrative, scientific, contextual, thematic, effective, collaborative, and student-centered (Menristekdikti, 2015).

The use of ICT as the impacts of technological advancement should be also applied in learning Linear Algebra. In UMK, it has a *Learning Management System* (LMS) in the form of *e-learning Sunan*. It could be used by the lecturers in the learning. Heretofore, the lecturers have assumed that *e-learning Sunan* is only to substitute the face-to-face meeting when the lecturer cannot attend his class. Moreover, conventional learning has not directed the students to participate in learning.

The findings showed that the *flipped classroom*-based learning model applied in learning mathematics was effective to improve the creativity, responsibility, and learning skill (Damayanti & Sutama, 2016). In another hand, other findings showed that the students learned with the flipped classroom-based learning model and mind mapping method had excellent achievement and high learning autonomies than those taught conventionally (Choiroh et al., 2018). However, the already mentioned findings only had a concept that the flipped classroom-based learning model was only done by replacing the function of classroom learning into learning at-home activity. Then, the homework that is usually worked at home would be completed at schools. This is in line with an argument that what is usually done at schools will be done at home. Then, the homework will be done after completing the learning in the classrooms (Bergmann

& Sams, 2012). This study is different from previous studies, because the applied learning that has been done before has not used e-learning to support *flipped classroom* learning.

Based on the problems and the existing findings, then active learning involving the students should be promoted. Besides that, the use of technology and *e-learning* could be also integrated into learning. Such learning could be promoted by implementing the *flipped classroom* model for the Linear Algebra course. *The flipped classroom* is a strategy provided by educators by minimizing the intensity of direct instruction in the teaching practice but maximizing the interactions among each other (Johnson, 2013). The *flipped classroom* learning is learner-centered. It consists of two parts with the interactive learning activity during the learning and the computer-based autonomous learning outside of the classroom learning (Bishop & Verleger, 2013). A teacher should facilitate the sources and the given materials before beginning the class (Ayçiçek & Yelken, 2018). It has the purpose to prepare the learners so they are ready in the classroom and to develop their autonomous learning. In this activity, the *flipped classroom* learning is learning combining the face-to-face meeting and online class. From this *flipped classroom,* learners are involved in the learning and their learning autonomy would be fostered.

The Linear Algebra course is expected to motivate and involve students actively. The lecturers' roles in delivering the materials become important roles to achieve the learning success. Through this *flipped classroom* learning, the lecturers could deliver the materials via *e-learning Sunan.* The students would also have an opportunity to learn the materials before joining the face-to-face course. Then, the lecturers could facilitate the students to discuss later in the face-to-face meeting.

This research is essential to do because this study accommodates the use of ICT for Linear Algebra learning. It has the purpose to reduce the students' dependency for the lecturers and it could make the information in *e-learning Sunan* as the various learning sources. The objectives of this best practice are: 1) describing the stages of Linear Algebra learning, 2) describing the implementation of the ICT-based *flipped classroom* on the Linear Algebra course, and 3) describing the students' learning outcomes.

METHOD

The best practice is a notion about a certain technique, method, process, activity, intensive, or *reward* that is more effective to reach success than other techniques, methods, or processes. The subjects were the first semester students in the academic year of 2019/2020, of the Mathematics Education Study Program, Universitas Muria Kudus. This research was conducted in the Linear Algebra course. The techniques of collecting data were test and non-test techniques. The test technique was used to measure the students' mathematics ability by using the learning outcome test instrument. The non-tests were used to measure the students' learning autonomies and learning observation. The tests consisted of a questionnaire and an observation sheet. The applied data analysis consisted of a qualitative description of the learning activities, mathematics ability, and the students' learning autonomies.

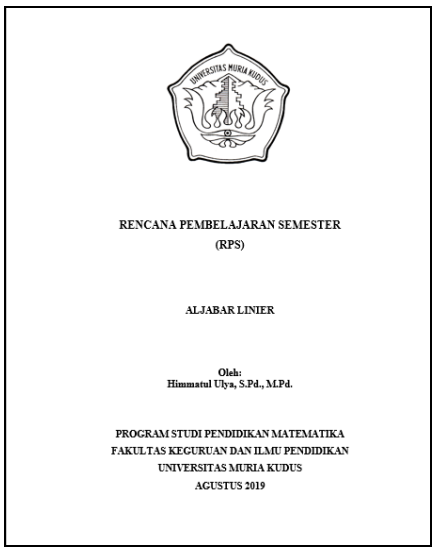
RESULT AND DISCUSSION

The Activity Steps to Promote the Linear Algebra Learning

1. Designing the learning

This learning activity was begun by coordinating the executive lecturer and the program coordinator of the Information and Communication Technology-based Learner-Centered (Program Pembelajaran Berpusat pada Mahasiswa Berbasis Teknologi Informasi dan Komunikasi (PBMBTI)). This activity consisted of the realization of the PBMBTI plan. It was done by arranging the course schedule, planning the materials to be delivered, planning the learning activity, and using the ICT for the learning.

The planning activity of the learning was realized into the PBMBTI socialization. *workshop blended learning*. It had a purpose to enhance the learning plan and to share the experience for designing qualified learning. The activity discussed comprehensively the significance, resourcefulness, content, and context of learning material, strategy, method, medium, and assessment. Thus, it would produce an innovative and challenging learning design. A *Workshop of blended learning* was required to prepare the concept of the *blended learning* implementation in the course for the PBMBTI executive lecturer. The PBMBTI executive lecturer applied the *Learning Management System* of sunan.umk.ac.id for his online learning. This sunan.umk.ac.id LMS is a developed LMS facility by Universitas Muria Kudus. The training results were used to compose the learning contents and media.



RENCANA PEMBELAJARAN SEMESTER
(RPS)

ALJABAR LINIER

Oleh:
Himmatul Ulya, S.Pd., M.Pd.

PROGRAM STUDI PENDIDIKAN MATEMATIKA
FAKULTAS KEGURUAN DAN ILMU PENDIDIKAN
UNIVERSITAS MURIA KUDUS
AGUSTUS 2019

Figure 1. The Semester Learning Plan (SLP)

2. Developing the content and learning media

The content and learning media development should be promoted through the use of *Focus Group Discussion* (FGD) among the lecturers and the PBMBTI coordinators. The FGD activity discussed the material content and the ICT-based learning media for the course. The content and the learning media produced by this activity were: (A) textbook, (b) the PowerPoint slide, (c) video, and (d) the course activation in sunan.umk.ac.id LMS account. The produced video in this content and the learning media development were online videos (from *Youtube*) that were relevant to the given materials. The videos should also support the students to learn a concept. The video could be used as a reference for the students to learn the material. The applied course for the PBMBTI program was the Linear Algebra. The course discussed the matrix. The

shown videos were such as how to solve matrix operation problems by using Ms. Excel.

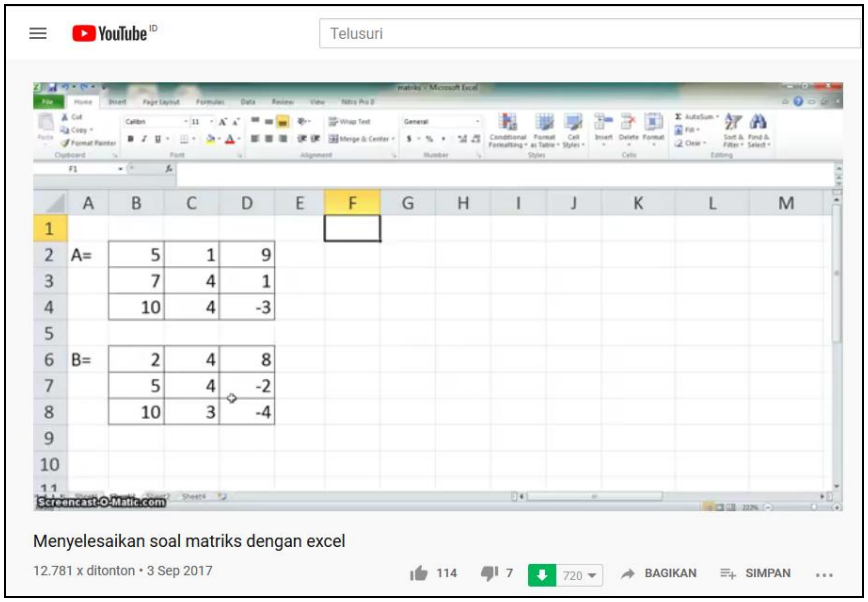


Figure 2. The Matrix Learning Video (Setyawati, 2017)

3. Uploading the learning materials

In the previous stage, the lecturer had developed the learning content and media to be applied in the course for a semester. The next stage required the lecturer to upload the materials in the *e-Learning*, the sunan.umk.ac.id. The uploaded materials consisted of *PowerPoint slides*, pdf formatted materials, learning videos, questions, tasks, and quizzes.

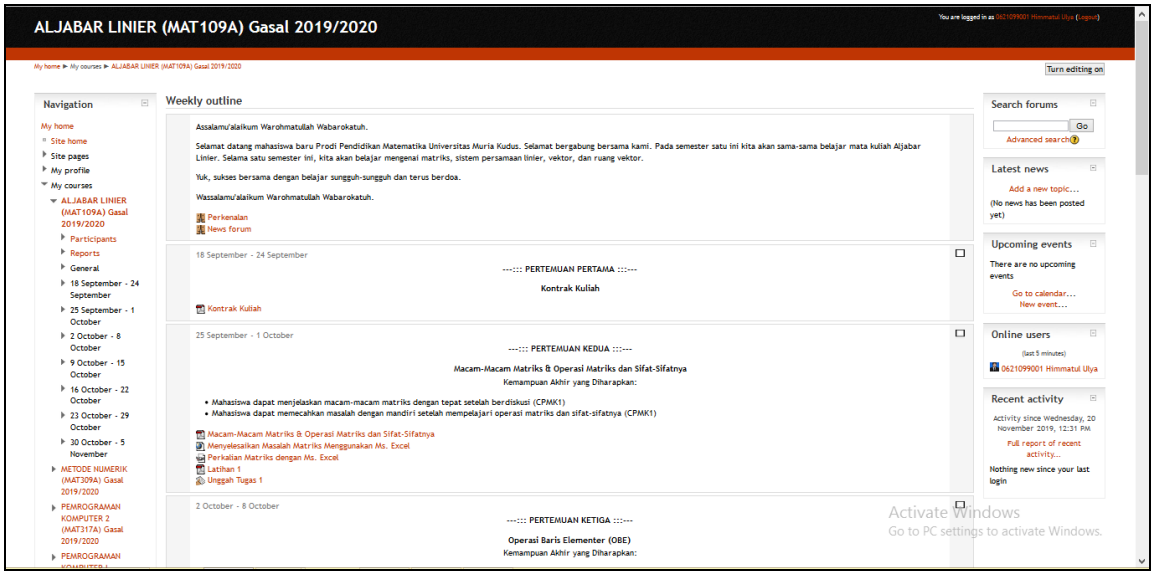


Figure 3. The Display of The E-Learning (sunan.umk.ac.id)

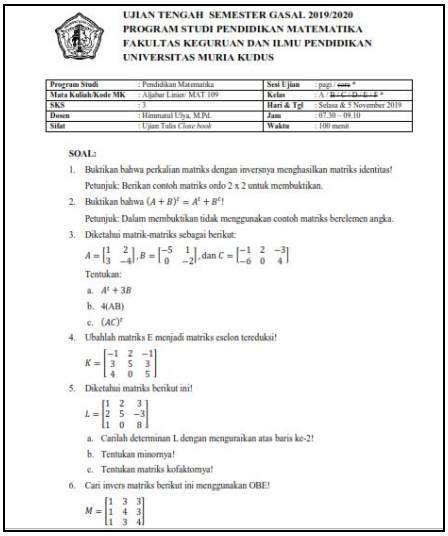
4. Using the ICT for the learning

In the implementation of the PBMBTI *blended learning*, the lecturer collaborated on the face-to-face meeting and the online classes. The courses were promoted by the lecturer via E-learning in the form of a site sunan.umk.ac.id created by the Education

Institution of Universitas Muria Kudus. Every lecturer and student had an account to access and use the LMS. The lecturer had uploaded the learning materials and media so the students could learn anywhere and anytime. The use of the ICT for the Linear Algebra course was also done by directing and providing opportunities for the students to seek other learning sources from the Internet accessed by mobile phones or laptop computers during the course. It had the purpose to provide wider virtual access for the students, to interact with the lecturer, to interact among the students, or to access various digital learning sources. Besides that, the used ICT took form into a computer program to solve problems concerning matrices. The students were guided to find the solution in solving problems and they were assisted by Ms. Excel.

5. Assessing

To measure the learning achievement, the lecturer assessed the students. The promoted assessment consisted of test and non-test techniques. They were used to measure the cognitive, affective, and psychomotor aspects of the students. The test was done by promoting a quiz and a Midterm Test. The quiz was done once in the fifth meeting. It had a purpose to measure the learning achievement concerning matrix inverse. The Midterm Test was used to measure the learning achievement of the cognitive aspect after half of a semester. It was done in the eighth meeting. The Midterm Test questions consisted of 6 essay questions. They were opened questions. Besides measuring the mathematics ability of the students, the lecturer also promoted the non-test assessment. It had a purpose to measure the affective aspect of the students such as learning autonomy and achievement motivation. It dealt with the applied Online learning that provided opportunities for students to learn autonomously. The learning autonomy is also correlated to the students' achievement motivations. Higher student's achievement motivation leads to higher awareness to learn autonomously. The measurements of the learning autonomy and achievement motivation were done by distributing a questionnaire. It was uploaded online to be filled by the students. Dealing with the psychomotor aspect, the lecturer assessed the students' performances and products while having group works.



UJIAN TENGAH SEMESTER GASAL 2019/2020
PROGRAM STUDI PENDIDIKAN MATEMATIKA
FAKULTAS KEGURUAN DAN ILMU PENDIDIKAN
UNIVERSITAS MURIA KUDUS

Program Studi	: Pendidikan Matematika	**Sesi Ujian**	: pagi / ~~siang~~ *
Mata Kuliah/Kode MK	: Aljabar Linier/ MAT 109	**Kelas**	: A / ~~B / C / D / E~~ *
SKS	: 3	**Hari & Tgl**	: Selasa & 5 November 2019
Dosen	: Himmatul Ulya, M.Pd.	**Jam**	: 07.30 – 09.10
Sifat	: Ujian Tulis *Close book*	**Waktu**	: 100 menit

SOAL:

1. Buktikan bahwa perkalian matriks dengan inversnya menghasilkan matriks identitas!
   Petunjuk: Berikan contoh matriks ordo 2 x 2 untuk membuktikan.
2. Buktikan bahwa $(A+B)^t = A^t + B^t$!
   Petunjuk: Dalam membuktikan tidak menggunakan contoh matriks berelemen angka.
3. Diketahui matrik-matriks sebagai berikut:
   $A = \begin{bmatrix} 1 & 2 \\ 3 & -4 \end{bmatrix}, B = \begin{bmatrix} -5 & 1 \\ 0 & -2 \end{bmatrix}$, dan $C = \begin{bmatrix} -1 & 2 & -3 \\ -6 & 0 & 4 \end{bmatrix}$
   Tentukan:
   a. $A^t + 3B$
   b. 4(AB)
   c. $(AC)^t$
4. Ubahlah matriks E menjadi matriks eselon tereduksi!
   $K = \begin{bmatrix} -1 & 2 & -1 \\ 3 & 5 & 3 \\ 4 & 0 & 5 \end{bmatrix}$
5. Diketahui matriks berikut ini!
   $L = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 5 & -3 \\ 1 & 0 & 8 \end{bmatrix}$
   a. Carilah determinan L dengan menguraikan atas baris ke-2!
   b. Tentukan minornya!
   c. Tentukan matriks kofaktornya!
6. Cari invers matriks berikut ini menggunakan OBE!
   $M = \begin{bmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{bmatrix}$

Figure 5. The Example of the Test Assessment

6. Feedback Facilitation

To measure the effectiveness and the satisfaction levels of the students toward the course, the PBMBTI executive lecturer made an online feedback questionnaire sheet as the for the students. The feedbacks covered the students' satisfaction levels toward the learning service, the learning source accessibility, and the learning material quality. According to the students, the applied learning services by the lecturer were excellent, interesting, joyful, and interactive. From the accessibility aspect, the learning source was accessible. Besides that, the students also had many references for learning. From the learning material quality aspect, the students argued that the materials were understandable and vary.

The Implementation of the ICT-based *flipped classroom* for Linear Algebra Course

In this course, *blended learning* was applied to the *flipped classroom* model. In the online activity, it was considered as a basic science preparation stage. It could be done by using expository and teacher-centered approaches. In another hand, offline activities could be used to explore the students' cognitions so that the experiences could be obtained during the learning.

At the beginning of the learning, the learners were prepared to join the course. They tried to solve the daily life problems given by the teachers. Then, the students were given a problem concerning a material to solve in a group. The material was uploaded by the lecturer in the *e-learning* platform. The students were facilitated to create groups. They were then allowed to find a solution stage via the Internet accessed from their Handphone or Laptop. They were then asked to solve the problems on the given Worksheet manually or utilizing the computer program. After discussing, they presented their results in front of other groups. Then, the other groups responded to them.

While discussing, several groups attempted to solve the problems with different methods instead of what had been stated in the book. It was caused by open-ended questions. They also adopted the ways as shown in the video. The videos were shared by the lecturer via the LMS to provide other references in solving the problems. While discussing, several groups were discussing together. Several groups worked on them individually first. Several groups divided the tasks manually, bu using the computer, and writing the discussion report on the available papers. A student labeled AR, usually was active. However, he was the fastest and the most accurate individual to solve the problem. All groups chose Ms. Excel program to solve the problems.

The learning lasted interactively. During the discussion, the students were also cooperative and actively communicated with their group mates. The learning was more meaningful because they discussed to find the solution together. The steps determined by the students were varied. The students that did not understand were found asking their peers to solve the problems. By using the Internet from the handphone or laptop computers, the students could find the learning reference directly. Thus, their cognition would last longer in their memories. The engaged hindrances were: (1) network problems when it was accessed outside of the campus, (2) the students were contused due to many references to solve the problems, (3) the size of the file was bigger than 5 MB and was difficult to upload, and (4) the discussion with 5 or 6 members was not effective.

The Students' Learning Outcomes

To measure the learning achievement, the lecturer assessed the students. It consisted of cognitive, affective, and psychomotor aspects. The cognitive aspect dealt with the students' mathematics ability and it was done by a test. The psychomotor aspect dealt with the students' learning activities and it was done by observation.

The students' learning outcomes, in terms of cognitive aspects, were the students' mathematics ability in the Linear Algebra taught by using the ICT-based *flipped classroom* as shown in Table below.

Table 1. The Students' Mathematics Ability

Scores	Predicates	The Numbers of the Students
85 ≤ the score ≤ 100	A	15
75 ≤ the score < 85	AB	0
67 ≤ the score < 75	B	8
61 ≤ the score < 67	BC	0
55 ≤ the score < 61	C	0
45 ≤ the score < 55	CD	5
35 ≤ the score < 45	D	0
0 ≤ the score < 35	E	1

Based on the Table, it shows that most students obtained the predicate of A. 51.72% of students joining the course had obtained excellent results. It meant *flipped classroom* learning provided a better learning outcome. In flipped classroom learning, it was found better because the students were more autonomous and ready to learn.

The students' learning outcomes, in terms of affective aspects, in the Linear Algebra taught by using the ICT-based *flipped classroom* are shown in the table below.

Table 2. The Students' Learning Autonomies

Criteria	The Numbers of the Students
Very Excellent	16
Excellent	13
Sufficient	0
Low	0

In Table 2, the students' learning autonomies were included in excellent and very excellent categories. The students had better learning autonomies to they were ready to learn in the classroom. When the learning applied a *flipped classroom*, the lecturer could be more interactive to his students and he could create various conditions and good learning situations either at home or in the classroom. It was done to realize the expected changes with purposes to get better learning outcomes or thinking ability.

The initial activity for implementing *flipped classroom* learning is designing learning that is carried out by means of *blended learning*. Thus, the lecturer could design the Semester Learning Plan accurately. This finding in line with Isti'anah, (2017) that the use of offline and online activities was expected to produce better output than traditional face-to-face activities. Harahap (2015) in his research also suggested that In content and learning media development activities, lecturers conducted FGD with PBMBTI coordinators. This FGD produced teaching materials that will be used for

lectures. In the produced learning materials, they were expected to facilitate the lecturers during the learning process

Other finding also contribute that in the implementation of the PBMBTI *blended learning*, the lecturer collaborated on the face-to-face meeting and the online classes. The online activities were directed to provide basic information on the learning. In another hand, the offline activities invited the students to bring their experiences that actualized the already presented basic science in the online activity (Sutisna et al., 2019; Sutisna et al., 2019). *Blended learning* is naturally a combination of humans and technology (Dwiyogo, 2018). Technology at this time is indispensable in learning. Students can take advantage of ICT when studying, while lecturers facilitate by directing students to search for learning resources on the internet during lectures. Thus, it could provide open learning access beyond the physical limitation of the conventional classes by using the website-based computer network and Internet support (Muthmainnah et al., 2019). Giving students opportunities to access virtual learning can be one way for students to actively learn. In addition, students can interact with lecturers and between students and access various digital learning sources. It is in line with a statement that a *flipped classroom* is a mixed-learning realization. It allows learners to learn new content online by watching videos that could be done at home. Then, what is conventionally done at home (i.e. Homework) will be completed at schools by the assistance of the teacher's guidance and more personal interaction (Nwosisi et al., 2016).

When offline learning takes place, students are actively discussing. By using open-ended questions, students try to solve problems in a different way from those in textbooks. By having these open-ended questions, the students expressed their creative ideas differently (Rahmatina & Ismi, 2019). The given problems were also understandable since they were related to their daily lives. Thus, students could construct their knowledge (Ulya, 2017). By using the Internet from the handphone or laptop computers, the students could find the learning reference directly. To find out the advantages and disadvantages of implementing learning, feedback activities are carried out. The feedbacks were used to evaluate the learning promotion and to influence the learning (Fyfe et al., 2012; Santos & Pinto, 2009). The most obstacle experienced by students is that of the internet network. The network problems were the most frequent problems occurring in online learning. It is in line with a study arguing online learning has an unstable internet connection problem (Pratiwi, 2020).

After the implementation of *blended learning*, an assessment is carried out to measure learning achievement. The assessment was carried out to measure the cognitive aspects of learning achievement. The questions used are in the form of descriptions and open questions. They had various correct answers or solutions to answer (Kurniawan et al., 2018). Thus, the students were demanded to think creatively to answer the questions. They were expected to pay attention and go beyond the standard process of solving a problem (Emilya et al., 2010). Other result found that student learning outcomes in the cognitive aspect get very good results. It meant *flipped classroom* learning provided a better learning outcome. It was in line with a conclusion of a study that there were differences in the students' learning achievements taught by *flipped classrooms* and direct learning (Khoirotunnisa' & Irhadtanto, 2019). In *flipped classroom* learning, it was found better because the students were more autonomous and ready to learn. The students' learning autonomies were included in excellent and very excellent categories. The implementation of the flipped classroom triggered the interaction process among the students, the students and the lecturer, and with their

learning environment. It had a purpose to create a behavioral change and learning autonomy (Maolidah et al., 2017; Mirlanda et al., 2019).

The contribution of this research is that learning can be applied by lecturers to improve learning outcomes and student learning independence. In times of pandemic, technology is very much needed in learning. Based on the Joint Decree of 4 Ministers regarding Guidelines for Implementation of Learning During the Corona Virus Disease 2019 (Covid 19) Pandemic, the green zone can conduct face-to-face learning (Mendikbud et al., 2020). This can be used as a reference in implementing *blended learning* during the pandemic in the green zone. Furthermore, this study has a limitation that the implementation of *flipped classroom* learning cannot be applied during the pandemic for areas other than the green zone because it combines face-to-face and online learning. This can be used as a reference for further research to develop *flipped classroom* learning that can be done in all zones.

CONCLUSION

The conclusions of this *best practice* were as follow: the activity steps to promote the Linear Algebra learning: (1) designing the course, (2) developing the content and learning media, (3) uploading the learning material, (4) using ICT for the learning, (5) promoting the assessment, and (6) providing feedback facilitation. The ICT-based *flipped classroom* model implementation on the Linear Algebra course was begun by providing a problem to be solved in a group. It was about certain material. The material was uploaded by the lecturer in *the e-learning* platform. The students were facilitated to create groups. They were then allowed to find a solution stage via the Internet accessed from their Handphone or Laptop. They were then asked to solve the problems on the given Worksheet manually or utilizing the computer program. After discussing, they presented their results in front of other groups. Then, the other groups responded to them. The average of the students' learning outcomes, in terms of cognitive aspect, was in the form of the students' mathematics ability in Linear Algebra learning taught by the ICT-based *flipped classroom* model. The ability reached a predicate of B while the students' learning autonomies in Linear Algebra learning taught by *flipped classroom* was categorized very excellently.

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AUTHOR CONTRIBUTION STATEMENT

This best practice, the HU designed and promoted the learning, collected and analyzed the data, and disseminated the best practice results.

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