



Conceptual Changes of Students in Thermodynamics in Physical Chemistry Course through the Implementation of Blended Learning

*Afadil, Sitti Rahmawati & Suherman

Program Studi Pendidikan Kimia/FKIP – Universitas Tadulako, Palu – Indonesia 94119

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Abstract

This study aims to determine the conceptual changes of students after participating in learning with a blended learning approach on Thermodynamics material. This research is a pre-experimental (pre-experimental design) with a Group Pretest-Posttest Design. The blended learning approach is applied using the Problem Based Learning model. The research sample was Class C Odd Semester 2019/2020 students, with 34 students who programmed Physical Chemistry courses. The instrument used is a two-tier multiple-choice test that includes concepts in Thermodynamics material equipped with a valid CRI. The blended learning approach is one approach that can be used that facilitates student activities in utilizing ICT through the delivery of materials, discussion of task complete within in the search for teaching materials on Thermodynamics material. The results showed that misconceptions still occur in every concept of Thermodynamics. The average reduction of misconceptions (MC) is 11.2%, the increase in the number of students to know concept (KC) classically is 19.2%, and the decrease in the number of students unknowing concepts (UKC) is classically 8.1%. Students' conceptual changes to the material of Thermodynamics are still low. Students are required to understand well the material's content related to basic concepts, mathematical equations (formulas), and the applicative forms of concepts in everyday life by the characteristics of the thermodynamic material.

Keywords: Conceptual change, misconceptions, thermodynamics, blended learning

Introduction

Concepts are generalizations and abstractions of facts and events that help understand the world around them (Dahar, 2011; Ibrahim, 2012). Conception develops a concept within a person (Suyono & Hariyanto, 2011). Based on their understanding of a concept, a person can be grouped into three, namely people to knowing concept (KC), unknowing concept (UKC), and misconceptions (MC). The misconception is a discrepancy between students' understanding of concepts with scientific knowledge formulated by scientists in their fields (Vrabec & Prokša, 2016). Conceptual change is changing the meaning of the existing conception towards a more scientific conception (Redhana et al., 2017). A student's conception results from his interaction with a concept that can lead to misconceptions if misinterpreted.

The phenomenon of misconceptions in students, students, teachers, lecturers, or anyone else should not be allowed because the occurrence of misconceptions in the initial concept will be a

barrier to the ability of the following academic process (Metin, 2011; Erman, 2017). Posner (in Kaya & Geban, 2012) suggests the conditions that must be met so that students' misconceptions can be changed, namely: (1) there must be dissatisfaction with existing concepts; (2) the new concept must be understandable; (3) the new concept must make sense; (4) the new concept must be practical or useful. Once these conditions have been met, students can experience a conceptual change.

Misconceptions require greater attention in learning chemistry. The occurrence of student misconceptions on chemical concepts because in chemistry courses, there are concepts that are not easy to understand unless they are related to something from everyday experience. According to Afadil et al. (2017), a complete and in-depth understanding of concepts needs to be introduced to students to improve thinking skills and knowledge of chemical concepts. Therefore, determining students' conceptions becomes very

*Correspondence:

Afadil

e-mail: afadil@untad.ac.id

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important, and further learning models are sought to prevent and reduce them.

Various research results found that misconceptions have occurred in several chemical concepts such as acid-base (Metin, 2011), stoichiometric (Nilawati et al., 2017), basic concepts in chemistry (Härmälä-Braskén et al., 2020), organic chemistry (O'Dwyer & Childs, 2017), covalent bonds (Erman, 2017), the reaction rate (Sunyono, 2014; Kaya & Geban, 2012), colligative properties (Sunyono, 2014), carbohydrates (Milenković et al., 2016), Acid-Base Concept (Pikoli, 2020), and chemical kinetics (Afadil & Diah, 2020). Several facts show that there is still an assumption that chemistry subjects in school are complex subjects to learn (Adesoji et al., 2017; Sanchez, 2017). The cause of this difficulty is because many chemistry subject matter is abstract (Olanmi, 2017; O'Dwyer & Childs, 2017), it is challenging to distinguish macroscopic and microscopic concepts (Hasanah et al., 2020), and Effendy (2014) explains that the fundamental problems in chemistry learning that cause misconceptions in students today are (1) the acquisition of an incomplete understanding of chemistry by students, and (2) the non-optimal development of higher-order thinking skills, (HOTS).

Various efforts were made related to efforts to reduce student misconceptions, including Afadil & Diah (2018) through the development of a science philosophy-oriented learning device that was developed to minimize the misunderstandings of SMA Negeri 1 Palu students for salt hydrolysis material from an average of 53.9% to 19, 6% or decreased by an average of 34.3%. Afadil & Diah (2019), by applying the PS-TRILOGY learning model oriented to local wisdom, were able to reduce student misconceptions (MK) on solution chemistry by 12.2%; able to increase the knowledge of concepts (TK) of students by 26.9%; and able to reduce do not know the concept (TTK) of students by 16.6%. From the results of these studies, it appears that there are still chemical concepts that are responded to by misconceptions.

Misconceptions must be attempted to be corrected with conceptual changes (Dahar, 2011). Based on the theory of conceptual evolution, cognitive conflict is one of the effective strategies to facilitate conceptual change. Competition can be caused by providing an anomaly or event contrary to the student's mind. This conflict will result in students not assimilating their knowledge of new concepts (knowledge). By itself, there will be a process of concept reconstruction due to events that challenge students to think more and question why their initial thoughts were not correct (Mumu et al., 2017). According to Atmacasoy & Aksu (2018) providing opportunities for various student characteristics causes independent, sustainable, and lifelong learning efforts to be more effective, efficient, and attractive. One approach that can be

taken to respond to technological and information developments is through a blended learning approach.

Blended learning or mixed learning is a learning approach that combines harmony, ously, structured, and system between the advantages of face-to-face and online learning. Mixed learning is becoming popular and the rapid development of Information and Communication Technology (ICT), namely the combination of internet networks and computing capabilities (IoT), enables more efficient and effective learning in developing student learning outcomes. According to Allen et al. (2007), the use of ICT in the learning process must be given proportional limits. The face-to-face and online learning implementation modes are integrated and systematically oriented to learning outcomes.

One of the efforts to provide information to lecturers and students about which components need improvement is to analyze changes in students' conceptions of study material in the learning. In addition, it can provide signs for lecturers to be aware of things that allow misconceptions to occur before and during the learning process. Through the analysis results, lecturers look for solutions to correct students' misconceptions. This is influenced by the causes of misunderstandings experienced by students. Therefore, lecturers are expected to find and choose methods and strategies for correcting misconceptions suitable for the situations and conditions faced by students. Based on the change in conception, the lecturer can determine the appropriate learning for a particular material as a characteristic. When handling student misconceptions comprehensively and specifically, it is hoped that students will have stability in understanding the concept of thermodynamics.

Methods

This research is a pre-experimental (pre-experimental design) with a one-group pretest-posttest design. In general, according to Fraenkel & Wallen (2009). The first step is to measure the pretest, then be treated and end with the post-test. The research sample is Class C odd Semester 2019/2020 as many as 34 students with 11 males and 23 females who program physical chemistry courses. The place of research is at the Chemistry Education Study Program, FKIP Tadulako University. The online learning media used is the Learning Management System (LMS) developed by FKIP Tadulako University. Learning is carried out using a problem-based (PBL) model through a blended learning approach. Learning materials (lesson plans, worksheets, textbooks, and instruments to determine changes in conception) that have been developed based on verification from a team of experts. The test result data obtained from the student's conception test is used as raw data to determine the pattern of shifting students' conceptions. The instrument used is a two-tier

multiple-choice test that includes concepts in chemical kinetics, equipped with a Certainty of Response Index (CRI). CRI is a technique to measure a person's misconceptions by measuring a person's level of confidence or certainty in answering each question given. According to Hasan et al. (1999), CRI is based on a fixed scale; in this study, the scale used is a scale of six (0-5), as presented in Table 1.

Table 1. Rating and Category Conception Students

Rating	Category
0	Guessed Answer: If you answered about 100%, predict or think ultimately.
1	Almost a guess: If in answering questions guesses element percentage between 75% - 99% or almost guess.
2	Not Sure: If in answering questions, percentage guesses element between 50% - 74% or unsure.
3	Sure: If in answering questions, percentage guesses element between 25% - 49% or confident.
4	Almost Certain: If the answer the riddle element percentage between 1% and 24%, or nearly specific.
5	Specific: If in answering questions is no element of guesswork at all (0%) or definitely.

The decision matrix for an individual student and a given question was analyzed using the matrix in Table 2. Matrix was derived from the student's answer based on combinations of correct or wrong answers and of low or high CR.

Table 2. Decision matrix for an individual student based on combinations of correct or wrong answers and low or high CRI

Criteria Answer	Low CRI (< 2.5)	High CRI (> 2.5)
Correct answer	Correct answer and low CRI	Right answer and high CRI
	Lack of knowledge (lucky guess)	Knowledge of correct concepts
Wrong answer	Wrong answer and low CRI	Wrong answer and high CRI
	Lack of knowledge	Misconceptions

Identification of student conceptions is intended to determine the percentage of students who experience misconceptions about certain concepts. The percentage calculation is determined by the number of students who participate in delusions divided by the total number. Identifying

misconceptions aims to determine which idea has a higher misconception among other concepts in learning material. Each group was determined by the average CRI score of students' correct answers (CRIC), the average CRI of students' wrong answers (CRIW), and the fraction of students who responded correctly (Fb). The CRIC score is obtained from the number of CRI students who answered rightly divided by the number of students who answered correctly. The CRIW score is obtained from the number of CRI students who answered incorrectly divided by the total number of students who answered incorrectly.

Meanwhile, Fb was obtained from the total number of students who answered correctly, divided by 100% (Nakhleh, 1992). The data were then analyzed using tables, percentages, and graphs. The results of data analysis are discussed narratively by comparing the results with the theory.

Results and Discussion

Thermodynamics material taught consists of concepts, namely: (1) work, (2) heat, (3) isobaric, (4) adiabatic, (5) isochoric, (6) heat capacity, (7) First Law of Thermodynamics, (8) enthalpy reaction, and (9) isothermal. The distribution of students' conceptions related to Thermodynamics was measured using a concept change test declared valid by the validator team. The tracking of changes in students' conceptions was carried out 2 (two) times, namely through a pretest and post-test in the form of a two-tier multiple-choice test that included concepts in Thermodynamics material equipped with CRI. The grouping of students' conceptions based on the results of the pretest in the categories of knowing concept (KC), unknowing concept (UKC), and misconceptions (MC) on each idea that represents chemical kinetics material is presented in Figure 1

Based on the data in Figures 1 and 2, it can explain that each concept was responded to by students in the UKC and MC categories on average. Of the nine concepts tested, all caused students to experience misconceptions. Most of the students (> 50%) were in the MC category, namely the First Law of Thermodynamics concept. While other ideas are more dominant, students respond with the UKC category. 14.4% (KC) students already have good initial knowledge regarding Thermodynamics material. The initial knowledge was obtained from understanding the Basic Chemistry course, which discussed Thermochemistry and other learning resources. According to Schunk (2011), students' prior knowledge contributes to forming or understanding internally knowledge obtained through personal interaction by asking their questions (self-questioning).

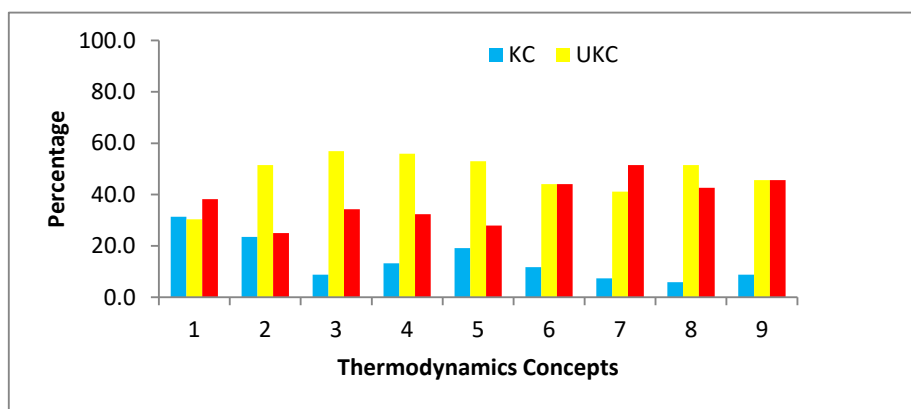


Figure 1. Comparison of the percentage of class C students of KC, UKC, and MC in the pretest thermodynamics material

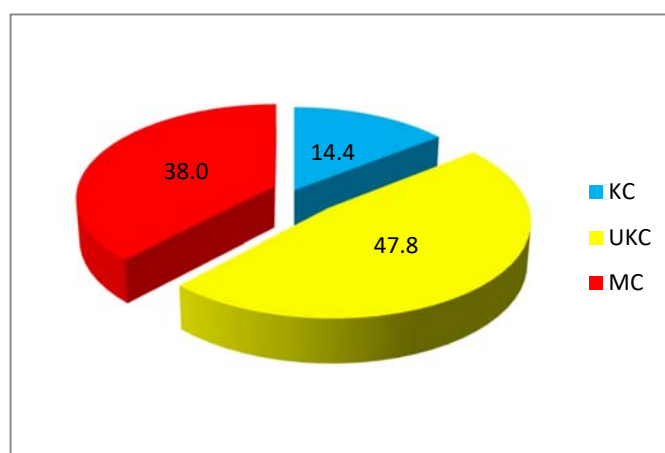


Figure 2. Average percentage of class C students of KC, UKC, and MC in the implementation of the thermodynamic material pretest

Identification of student conceptions in groups is used to determine the concept suspected of having the most substantial misconception from the nine (9) concepts tested. Identification is based on CRIC, CRIW, and Fb data for each test item representing the concepts in the Thermodynamics material. CRIC, CRIW, and Fb data calculated from the pretest results are presented in Figure 3.

According to Hasan et al. (1999), misconceptions occur and have a solid classical impact if the average CRIW value ($2.5 < \text{CRIW} < 5.0$) and $\text{FB} < 0.5$. Based on the CRIW and FB values in Figure 3, it appears that there are students who experience misconceptions for every concept tested, but the impact is not classically strong. From the results of the conceptual analysis, students are more dominant in the UKC category, namely 5 of 9 concepts (55.6%) students who respond $> 50\%$, while for the MC category, only 1 of 9 ideas (11.1%) replies $> 50\%$. This shows that the concepts taught in the Thermodynamics material have an easier chance of being converted into Kindergarten. Changing someone from UKC to KC is more

accessible than changing MC to KC. There is difficulty changing one's misconceptions (misconceptions) into scientifically acceptable conceptions (actual concepts); someone even grafts their new knowledge onto a conceptually incorrect basis. After learning with a blended learning approach on Thermodynamics material based on the semester lesson plan (RPS), we get a picture of changes in the conception of Class C students according to Figure 4.

Based on Figures 4 and 5, it appears that, on average, each concept is still responded to by students with misconceptions but experiencing conceptual changes compared to the pre-conception/pretest. It seems that all of the nine ideas tested still cause students to experience misunderstandings. However, the nine concepts were responded to by misconceptions $< 50\%$ experienced reduction but could not be eliminated. The identification results are based on CRIC, CRIW, and Fb data for each test item representing the concepts in the Thermodynamics material presented in Figure 6.

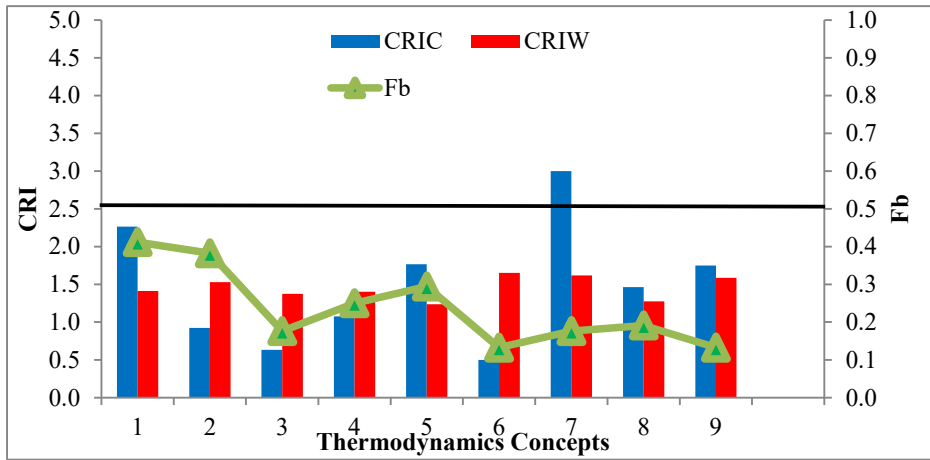


Figure 4. Comparison graph of CRIC, CRIW, and Fb pretest class C students for thermodynamics

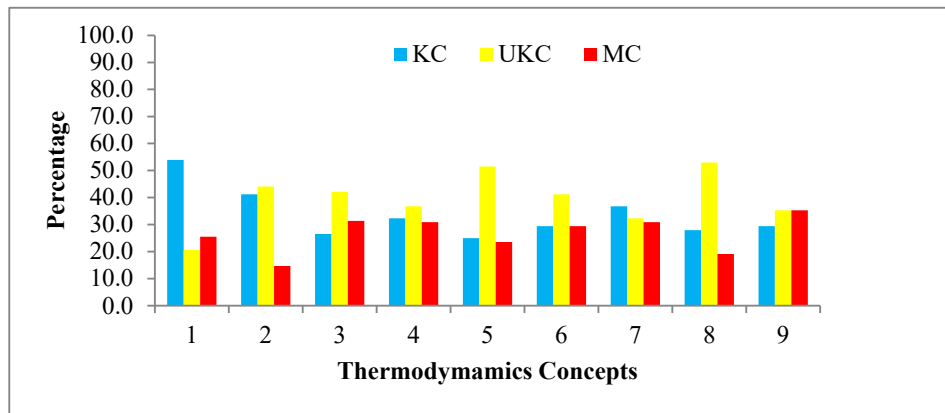


Figure 5. Comparison of the percentage of class C students of KC, UKC, and MC in the posttest implementation for thermodynamics materials

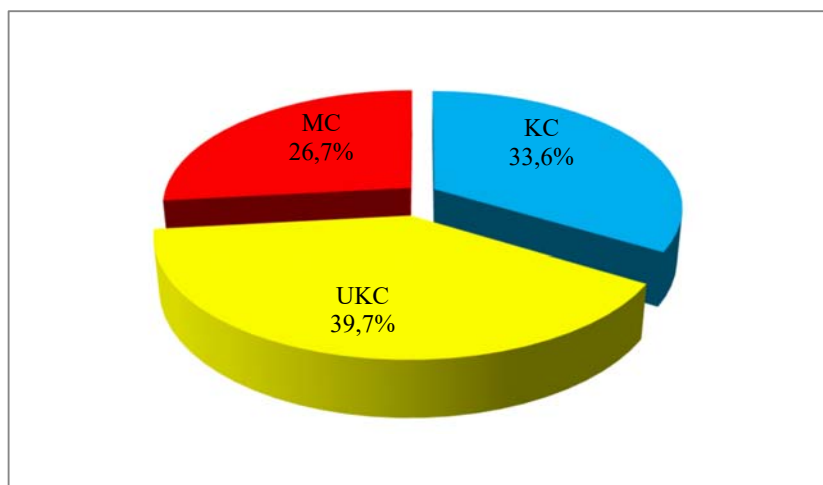


Figure 6. Average percentage of class C students of KC, UKC, and MC in the posttest implementation of thermodynamics materials

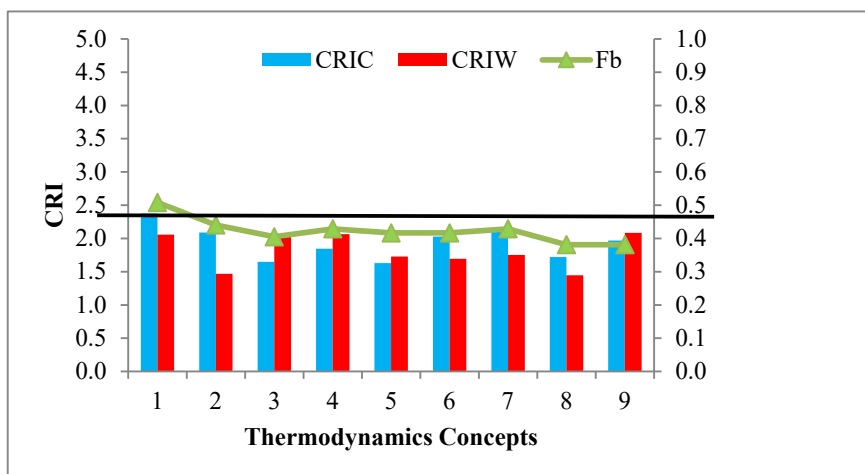


Figure 7. Comparison graph of CRIC, CRIW, and Fb posttest for class C students in thermodynamics

Comparison of student concepts on learning approach from the pretest and post-test Thermodynamics material through a blended results can be seen in Table 3.

Table 3. Comparison of percentage of misconception (MC), knowing concept (KC), and unknowing concept (UKC) of students on pretest and post-test of thermodynamics material

No	Concepts	MC (%)			KC (%)			UKC (%)		
		Pretest	Posttest	Reduct	Pretest	Posttest	Ride	Pretest	Posttest	Reduct
1	Effort	38.2	25.5	12.7	31.4	53.9	22.5	30.4	20.6	9.8
2	Heat	25.0	14.7	10.3	23.5	41.2	17.6	51.5	44.1	7.4
3	isobaric	34.3	31.4	2.9	8.8	26.5	17.6	56.9	42.2	14.7
4	Adiabatic	32.4	30.9	1.5	13.2	32.4	19.1	55.9	36.8	19.1
5	Isochoric	27.9	23.5	4.4	19.1	25.0	5.9	52.9	51.5	1.5
6	heat capacity	44.1	29.4	14.7	11.8	29.4	17.6	44.1	41.2	2.9
7	1st Law of Thermodynamics	51.5	30.9	20.6	7.4	36.8	29.4	41.2	32.4	8.8
8	Reaction Enthalpy	42.6	19.1	23.5	5.9	27.9	22.1	51.5	52.9	-1.5
9	isothermality	45.6	35.3	10.3	8.8	29.4	20.6	45.6	35.3	10.3
10	Average	38.0	26.7	11.2	14.4	33.6	19.2	47.8	39.7	8.1

Pretest scores are used to determine students' initial conceptions, while post-test scores obtained by students describe student learning outcomes after attending lectures through a blended learning approach. The results research conducted by Dziuban et al. (2004) found the blended learning approach has the potential to improve student learning outcomes and also reduce dropout rates compared to fully online learning; in addition, it was also found that the learning model with the blended learning approach is better than face-to-face learning.

Based on Table 3, the conceptual changes that occurred after the application of the blended learning approach only had a minor impact, namely: the average reduction in the MC was 11.2%, the increase in the number of students to classical KC is 19.2%, and the decrease in the number of students who were classically UKC as much as 8.1%. Based on these results, the application of the blended learning approach gives positive results in changing students' conceptions of the Thermodynamics material. However, there are still misconceptions about each of these concepts. This shows that lecturers still need to pay attention

to the characteristics of study materials in applying an approach/method/learning model. Regarding this condition, according to Allen et al. (2007), in using the blended learning approach, both in the perspective of lecturers and students, there are several good practice models. Study programs can apply various mixed learning models, such as rotation models, flex models, self-blend models, enriched virtual models, or flipped learning, but what must be considered is the suitability of the learning environment and adapting to the characteristics of the learning material.

Based on the results obtained, it appears that, in general, students still experience misconceptions about each concept in the Thermodynamics material. According to Dahar (2011), misconceptions are possible due to student interactions with lecturers or textbooks. The process of forming misunderstanding in learning, especially at the primary level, is as follows: (1) a person tends to base his thinking on things that appear in a problem situation, (2) a person only pays attention to certain aspects in a situation, is more likely to interpret a phenomenon. And in terms of the absolute nature of things, not in terms of interactions between the elements of a system, (3) A person is more likely to pay attention to change than a stationary situation, (4) his way of thinking tends to follow a linear causal sequence, (5) A person has various connotations that more inclusive and global, and (6) a person often uses different ideas to interpret situations that scientists use the same way.

The occurrence of misconceptions can also be caused by ideas that arise from the minds of personal students. These ideas are generally less scientific, and if the lecturer does not try to see the ideas that students have before introducing the concept, it will result in misconceptions. So far, the learning of physical chemistry courses has been carried out off-line with material because it contains basic concepts, many equations or formulas, and practicum. The material's content is basic concepts, mathematical equations (formulas), and the applicative forms of ideas in everyday life. The results of this study illustrate that lecturers and students still need to make more effective efforts to improve their understanding of concepts. Efforts should be made continuously to improve knowledge content. Prospective chemistry teachers must acquire good chemistry knowledge to transfer the correct expertise to students. According to Fatokun (2016), developing a learning approach involving new ideas and discussions will help students identify and reduce their misconceptions.

Conclusions

Responding to the development of Information and Technology in learning, various effective ways to improve students' conceptual understanding must be implemented. Students need to obtain the correct concept in each learning material to correct misconceptions in other materials. Thermodynamics is one of the learning

materials that students often respond to with misunderstanding. The blended learning approach is one approach that can be used that facilitates student activities in utilizing ICT through the delivery of materials, discussion of task completion, and training in the search for teaching materials on Thermodynamics material. The results showed that misconceptions still occur in every concept of Thermodynamics. The average misconception reduction (MC) is 11.2%, the increase in the number of students to know concepts (KC) classically is 19.2%, and the decrease in the number of students of unknowing concepts (UKC) is classically is 8.1%. Students' conceptual changes to the Thermodynamics material have improved concept understanding.

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