Analyzing types of interaction in nuclear magnetic spectroscopy online discussion forums that affects student learning outcomes

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Abstract. Many research shows that interaction can increase concept understanding. Course interaction can be categorized in student-student interaction and student-lecturer interaction. Strong interaction can increasing students high order thinking skill. Learning design begins to pay attention to that interaction effect. Interaction can be done online and lead to cognitive understanding. This qualitative descriptive research aims to describe the cognitive process in an online discussion, specifically in analytical chemistry course. They learn about nuclear magnetic spectroscopy that most used in both qualitative and quantitative analytical chemistry. The subjects are seven groups consists of three chemistry students in their third year. They have three worksheets to discuss in three weeks about basic principal, instrument, spectrum, and experimental design in Nuclear Magnetic Resonance spectroscopy. Data sources are their online discussion transcript obtained from their elearning discussion forum. They also have pretest and posttest to analyze N-gain score. Their discussions are analyzed using coding categories to count the number of meaningful interaction. The trend of n-gain score and number of meaningful interaction are analyzed. Type of interaction that showed is ARA, ARC, ARI, DRA, DRI, and DRC. Results show that gain score correlates with number of meaningful interactions.

1. Introduction

Improvement in techonology enhances communication between student and lecturer, and among students. Classroom discussion has extended to an online forum, where students continue discussion on related topics. Online learning also grows in higher education. The Sloan Consortium reports 6.7 million student in higher education took at least one online course [1]. The growth rate of online enrollment is 300-400% that of classroom enrolment [2].

Online course enrolement is in line with online interaction, especially in learner-learner interaction. Awareness of the existence of interaction and engaging learning is in line with the potential of internet and technology to connect learners [3]. Social technology tends to be effective in encouraging

collaboration and community building on online and blended learning [4]. In online learning, participants are dispersed geographically and learn at different times (asynchronous) with visual contacts are few or nonexistent[5]. Online learning prioritizes interaction to provide opportunities for students to apply concepts that have been obtained with unlimited time in class meetings [6]. The use of online collaboration tools, such as online forum, has potential to facilitate the interaction of participants and group activities in a web-based learning environment, and allow students to share discussions and ideas[7]. Participation in interaction among students increases in internet-based activities rather than traditional classes[8]. Interaction happened is learner-learner interaction. Based on Hirumi [9] interaction between students is in the second level, it is a visible part of online learning. The interaction that takes place between individual students or when the students are assigned to work in a small group. Communication tools must be available for students to share and exchange ideas [10].

Online discussion of learners can be synchronous discussion and asynchronous discussion. So reciprocity happens quickly and sequentially. The synchronous discussion can be done in an online discussion forum. The online discussion forum is for students to discuss the topic. The lecturer serves as the facilitator in the discussion. Lecturer encourages students to discuss, also besides educators guide and direct students to gain a proper understanding. The benefit of synchronous discussion is it promotes learning effectiveness [11]

Many studies show that interaction can increase learning outcomes, one of them is cognitive understanding. High order thinking, one of the cognitive abilities, affected by students and strong lecturer interaction [12]. Learning materials can be better understood by collaborative learning and interaction [13]. Interaction in discussion forums exist in a variety of online learning platforms, such as e-learning platforms (Edmodo, Moodle, etc.) or mobile platforms (Line, WhatsApp, etc.). Online forums provide opportunities for students to not only cooperate but also collaborate to develop knowledge [14].

Online interaction leads to social presence in course. Social presence had been identified to be a factor in enhancing quality of learning [15]. Previous study found that interactions are a key element for successful learning experiences in online learning environment [16] On the contrary, LaPointe & Gunawardena [17] found no evidence for a positive relationship between interaction and perceived learning outcomes.

1.1 Nuclear Magnetic Spectroscopy

Problems in analytical chemistry begin with identification of what is present in the sample. It can be analysed both qualitative and quantitative chemistry. Most qualitative analysed methods are nuclear magnetic resonance. First, nuclear magnetic resonance are only can be used to identify position of ^{1}H in molecule structure of sample. It had been strengthen with Fourier Transform and Superconductor Magnet. Nuclear Magnetic Resonance can also identify ^{13}C and other nuclei.

Nuclear Magnetic Spectroscopy works based on absorption spectroscopy. Absorption spectroscopy focused in photon absorption by the analyte, exciting the analyte from a lower-energy state to a higher-energy state [18].

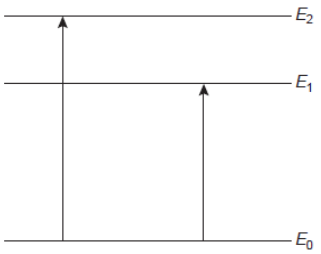


Figure 1. Simplified energy levels showing absorption of a photon

Nuclei has spin, electrically charged and behave like a magnet. In NMR Spectroscopy method, energy transfer takes place at radio waves wavelength that corresponds to radio frequencies and promotes higher spin levels. Higher energy spin levels generates a magnetic field in the opposite direction to the external magnetic field. When the spin returns to its base level, energy is emitted at the same frequency. Lower energy spin levels generates a magnetic field in the direction to the external magnetic field. The signal that matches this transfer is measured in many ways and processed in order to yield an NMR spectrum for the nucleus concerned. The precise resonant frequency is dependent on the effective magnetic field at the nucleus. This field is affected by electron shielding which is dependent on the chemical environment. When an analyte is analyze by ^{1}H NMR, every position of ^{1}H in molecular structure of analyte gives different spectrum based on their chemical environment. Figure below show the different of proton spectrum of cyclohexane and water analyzed by 400 MHz NMR.

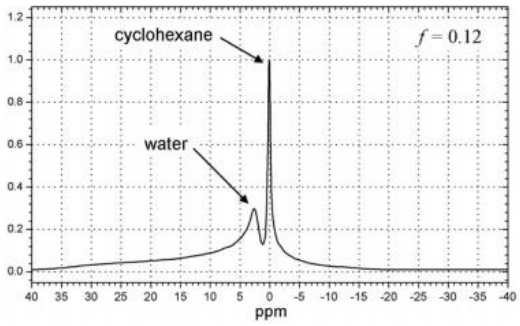


Figure 2. 400 MHz proton spectrum of nanoporous glass Vycor [19]

Nuclear Magnetic Resonance is a part of analytical chemistry that learn by student. In this material, students learn about principle of analyzation using Nuclear Magnetic Resonance. They also learn to analyze spectrum resulted. They have to differentiate NMR method with another modern analytical methods such as Gas Chromatography or Mass Spectroscopy. They have to analyze combination of NMR with another method to achieve the purpose of analyzing samples required.

1.2 Task

Interaction needs to be activity-based to encourage active learning [9]. Task must be designed to meet learning outcomes. Online interaction happens in online small groups. All activity must be written in worksheet clearly. There are three activity or three worksheet. First worksheet contains basic principle of Nuclear Magnetic Spectroscopy. Second worksheet contains about Nuclear Magnetic Spectroscopy instrument and workflow. In the third worksheet, student have to analyze about Nuclear Magnetic Spectroscopy research.

First worksheet is aimed for student to understand about nuclear magnetic resonance and properties. Student learn about basic principal of Nuclear Magnetic Resonance method. Questions given are about the importance of using Nuclear Magnetic Resonance method to analyse sample, basic principal of how Nuclear Magnetic Resonance works, definition of terms used such as NMR silent and spin quantum number, and effect of external magnetic field in Nuclear Magnetic Resonance.

Second worksheet is aimed for student to understand about part function in Nuclear Magnetic Resonance instrument and predict molecular structure based on spectrum resulted by Nuclear Magnetic Resonance. They have to explain steps in analyzation using Nuclear Magnetic Resonance instrument. The have to detail what part used in every step. Some parts have to differentiate in order to achieve analyzation required, such as probe sample. They have to understand why TMS (tetramethylsilane) is accepted internal standard for calibrating chemical shift for ^{1}H and ^{13}C NMR spectroscopy. The spectrum of NMR with TMS as internal standard is graphed below.

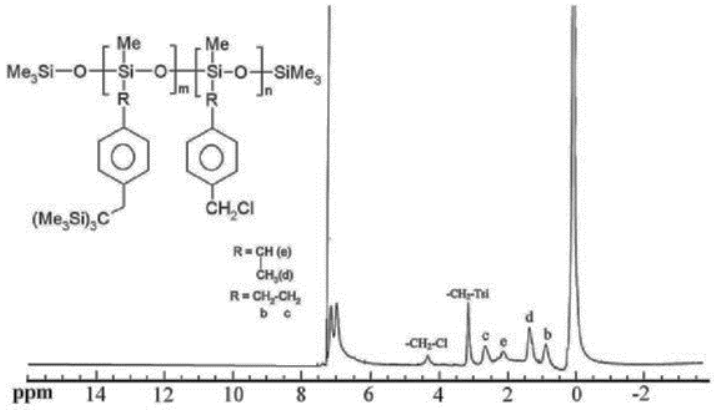


Figure 3. ^{1}H NMR spectrum of trisyl modification of epoxy- and chloromethyl-polysiloxanes [20]

They have to analyze peaks height in spectrum resulted ^{1}H NMR spectroscopy and its reasons. Figure 3 shows that there is highest peak in 0 ppm. It is the peak of TMS. Because TMS does not experience chemical shift like other hydrogen.

Third worksheet is about learning NMR method based on recent research. They have to understand why researcher use NMR and how to analyze the data. They have to design an experiment using NMR to apply their understanding.

1.3 Coding Categories

Coding categories is The Type of Interaction in Online Discussion Forum

Type of Interaction		**Characteristic**
Code	**Name**	
IM	Initial Message	Statement that leads to agreement or disagreement from other participant
ARA	Agreement with Assertion or Claim	Strong acclimation, impose other opinion
ARI	Agreement with Information	Provide new information, opinion, suggestion, or sharing experiences.
ARC	Agreement with Request Clarification	Questioning for clear concept by requesting answers
DRA	Disagreement with Assertion or Claim	Strong acclimation, impose other opinion
DRI	Disagreement with Information	Provide new information, opinion, suggestion, or sharing experiences.
DRC	Disagreement with Request Clarification	Questioning for clear concept by requesting answers

Table 1. Type of Interactions in Online Discussion Forum by Khlaif [21]

2. Methodology

This mix method study was to identify the type of interaction happened and describe a relation between number of meaningful interaction and learning outcomes in nuclear magnetic spectroscopy course. Subjects were seven groups consist of three students who took the course of analytical chemistry in their third year. The subject are familiar with online learning because they have been used before. They get pretest and posttest about Nuclear Magnetic Spectroscopy. They uses elearning forum to discuss about their worksheet. They get three worksheets to do in three weeks. At the end of three weeks, all discussion transcripts are downloaded to analyze. To fulfill the objectives, research is limited to students interaction. Only discussions that reference to topics are selected. Content analysis, as a research technique for quantitative description of the content of communication, is adopted to analyze and determine type of interaction in all groups. Content analysis involving reading each discussion message was conducted using Type of Interaction in Online Discussion Forums [21]. Using the coding categories (see Table 1), first message categorized as Initial Message, which attempt to initiate a conversation. Second message categorized as agreement or disagreement related to Initial Message. Agreement categorized as ARA, ARI, and ARC. Disagreement categorized as DRA, DRI, and DRC. Score of pretest and posttest for every student are collected and N-gain score in every group is calculated. N-gain score is calculated using this formula.

$$Ngain\ score\ (g) = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Criteria of N-gain score [22] is described below.

Table 2. N-gain Score Criterion

N-gain score	Criteria
g > 0,70	high
0,30 ≤ g ≤ 70	medium
g < 0,30	low

3. Result

Data were analysed over seven groups in three weeks. Discussions are carried out to lead conceptual understanding in Nuclear Magnetic Spectroscopy topic. This example shows all of the interactions happen in the online discussion forum. Student-student interaction is shown by students answering questions then being responded to by other students. Interactions that occur are related to topic. Data were analysed by coding categories. An interaction is considered meaningful if it has reason in agreement or disagreement feedback. Therefore, statement that considered as meaningful interaction is ARA, ARI, ARC, DRA, DRI, and DRC.

Example of ARA, ARI, ARC, DRA, DRI, and DRC in online discussion forum as decribed below.

1. ARA (Agreement with Assertion or Claim)
   Agree with Reason and Assertive/Claim is an agreement with assertion or claim. Student 1 and Student 2 discuss about NMR spectrum for ethanol. Questions in worksheet is about why 3rd peak is highest and where is peak of hydroxyl group. NMR spectrum for ethanol is shown below.

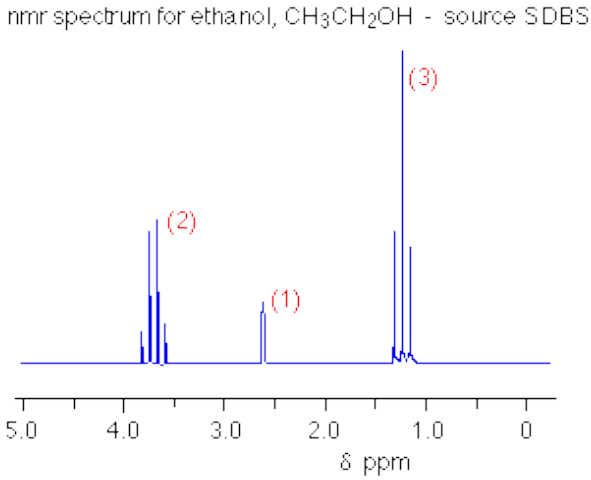


Figure 4. NMR Spectrum for Ethanol [23]

Student 1 gives initial message. Statement from student 2 which coded to ARA such as follows:

Student 1: "Hydrogen in hydroxyl group (-OH) and hydrogen in next carbon is not interacted to produce splitting. Peak of hydroxyl group is a single peak, singlet. Left peaks is from hydrogens in CH_2. Left peaks is quartet due to three hydrogens from CH_3. Hydroxyl group could not affect splitting here. "
Student 2: "OK. Next to CH_3, there are 2 neighbor H atoms, so it could be triplet. Next to CH_2, we can see four neighbor H atoms. –OH affected by two neighbor H atoms from CH_2."

Student 2 said "OK" which shows her agreement about student 1's initial message. Then Student 2 explain her claim about peaks and splitting in NMR spectrum for ethanol.

2. Agree with Reason and Information (ARI)
Agree with Reason and Information is agreement with reason and additional information. Additional information could be new idea, opinion, suggestion, or sharing experience.

Student 1: "Question no. 9. The answer is because it could results magnetic field fluctuation."
Student 2: "Yups. Magnetic field sould be stable. High stability of magnetic field leads to high accuracy in seconds. I am pretty sure that sensitivity and resolution also advanced."

Student 1 gives initial message and student contains answer to question number 9. Feedback from student 2 still in line with statement from student 1 but student 2 adds some new information. It coded to ARI. The similarity of meaning from these sentences indicate agreement.

3. Agree with Reason and Clarification (ARC)
Agree with Reason and Clarification is a statement of agreement with the reasons are accompanied by requests for clarification or requests for information. An indicator of ARC is asking questions for more concepts clearer or more information. Examples of statement coded as ARC are as follows.

Student 1: "I think NMR is important because it can determine compounds up to its structure, can also be used for complex molecule."
Student 2 : "Is the compound in question is an organic compound and inorganic?"

The first statement by student 1 shows his/her opinion about its importance use of NMR. The feedback given by student 2 does not contain disapproval. Besides the feedback given by student 2 in the form of questions that require clarification from student 1.

4. Disagree with Reason and Assertive / Claim (DRA)

Disagree with Reason and Assertive / Claim is a disagreement with reasons accompanied by the existence of alternative ideas and support contrary opinions. Examples of statement coded to DRA as follows.

Student 1: "I think chemical shifts can also be affected by magnetic fields."
Student 2: "Magnetic fields are not able to cause chemical shifts because chemical shifts involve a chemical reaction."
The first statement by student 1 shows student 1's understanding that chemical shift can also be affected by magnetic fields. Contradictions of opinion are seen in student 1 and student 2 statements. The feedback given by student 2 mentioned the reason for his disapproval. These reasons can also be considered as new ideas which is used against student 1's opinion.

5. Disagree with Reason and Information (DRI)

Disagree with Reason and Information is a statement of disagreement and the reason is accompanied by new suggestions. Examples of statement coded DRI as follows.

Student 1: "I think factor that affects chemical shift is electron density."
Student 2: "If you look at the instrument analysis book page 176, factor affects the chemical shift of a nucleus is the surrounding environment. The chemical shift depends on the chemical environment of a proton, while the chemical environment of a proton depends on its shielding effect by electrons in the environment of the proton."

The initial statements of student 1 showed their understanding of factors that influence chemical shifts. Student 1 said that factor affects chemical shift is electron density. Then student 2 said factor affects chemical shift is chemical environment. Student 1 and Student 2 show contradiction. But student 2 also provides new information about shielding effect.

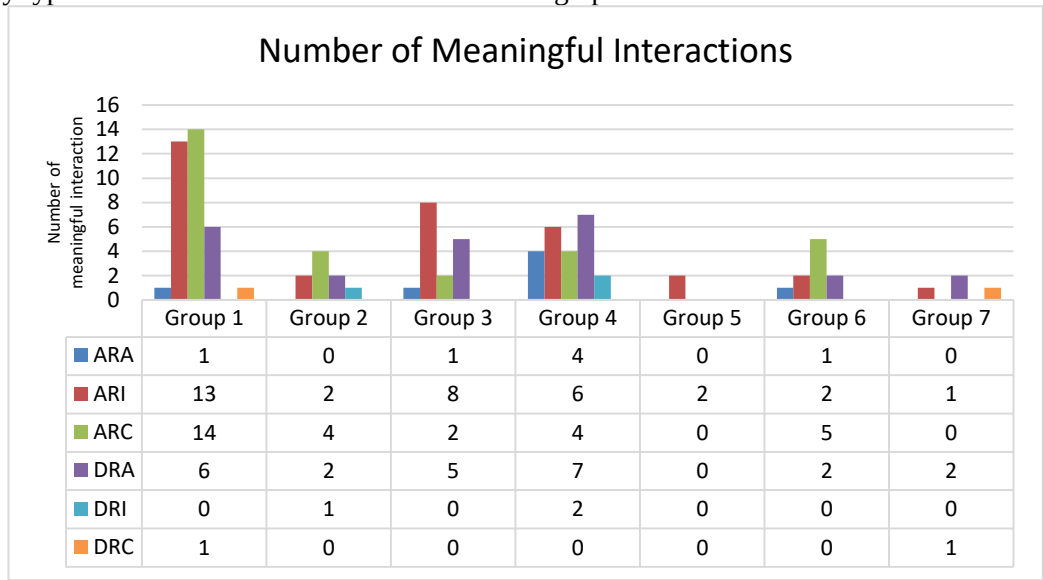
9. Disagree with Reason and Clarification (DRC)

Disagree with Reason and Clarification is a statement of disagreement accompanied by requests for clarification or requests for information. The indicator of the DRC is also in the form of asking questions for the concept clearer or more information. Examples of posts that are coded as DRC as follows.

Student 1: "I think the answer to number 9 is the frequency is not homogeneous."
Student 2: "I think your answer is no appropriate with this concept. What do you mean by frequency not homogeneous? How come?"

The first statement from student 1 shows the answer for number 9. But this statement is different from what was stated by student 2. Student 2 requests clarification from student 1. It can be seen from the form of the question ("how come?") shows student 2 does not agree with student 1 answer so it requires
clarification.

Every type of interaction is counted and resulted in graph below.



	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
ARA	1	0	1	4	0	1	0
ARI	13	2	8	6	2	2	1
ARC	14	4	2	4	0	5	0
DRA	6	2	5	7	0	2	2
DRI	0	1	0	2	0	0	0
DRC	1	0	0	0	0	0	1

Figure 5. Type of Interaction in every groups.

Total number of meaningful interaction as resulted below.

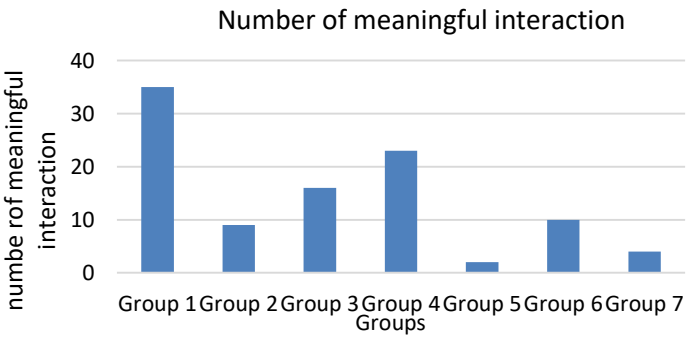


Figure 6. Total number of meaningful interaction in every groups.

The diagram shows that highest meaningful interaction are in group 1 and lowest is group 5. Average of meaningful interaction is 11 statements. N-gain score is calculated from pretest and posttest score resulted in Table 3.

Table 3. Result of Pretest and posttest, n-gain score, and number of meaningful interaction

Groups	**Pretest Average Score**	**Postest Average Score**	**N-Gain Score**		**Number of Meaningful Interaction**
			Score (in %)	**Criteria**	
Group 1	31	81	72	high	35
Group 2	22	75	68	medium	9
Group 3	19	64	55	medium	16
Group 4	21	85	81	high	23
Group 5	17	58	50	medium	2

Groups	Pretest Average Score	Postest Average Score	N-Gain Score		Number of Meaningful Interaction
			Score (in %)	Criteria	
Group 6	24	71	62	medium	10
Group 7	29	60	43	medium	4

Average of pretest score is 23,3. Average of posttest score is 70,6. There is two groups with high n-gain score and five groups is medium. Range of n-gain score is between 0,43-0,81. Trend of N-gain score and number of meaningful interaction showed in diagram below.

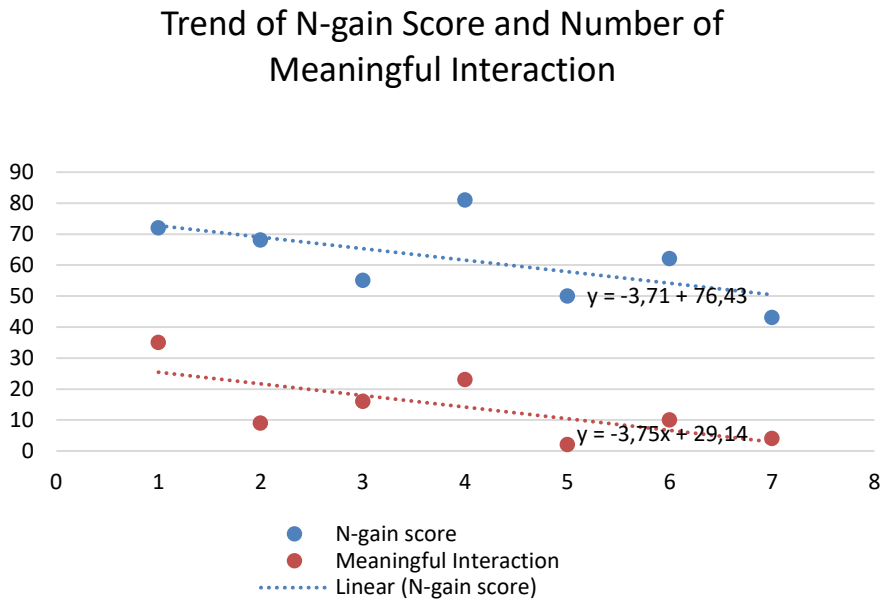


Figure 7. Trend of N-gain score and Number of Meaningful Interaction

4. Discussion

4.1 Type of Interaction

Type of interaction is described here (see Figure 1). The highest type of interaction in group 1 is ARC (14). This number also considered highest in all groups. The lowest number is DRC (1). There is no DRI in this group. ARA (1) and DRC (1) has same number. Data shows that group 1 has more agreement than disagreement. ARC (4) is the highest type of interaction in group 2. This group does not have ARA and DRC interaction. ARI (2) and DRA (2) has same number. Group 2 also has more agreement than disagreement. Group 3 has second highest ARI (8) in overall groups. But it is the highest type of interaction in their group. There is no DRI and DRC in this group. ARA (1) is the lowest type of interaction.

Group 4 shows that DRA (7) is the highest type of interaction. ARA (4) and ARC (4) has same number. Agreement also shows more than disagreement. There is no DRC type of interaction. DRI (2) is the lowest interaction in this group. Only ARI (2) that showed in group 5. It means that agreement is more than disagreement. There is no interaction which is disagreement. The highest type of interaction in group 6 is ARC (5). It is the second highest of ARC in overall groups. ARI (2) and DRA (2) also has same number. The lowest is ARA (1) in this group. There is no DRI and DRC interaction in this group.

ARI (1) and DRC (1) shows same number in group 7. The highest interaction is DRA (2). But it is the lowest DRA interaction in overall groups. There are three type of interaction that don't appear in group 7, ARA, ARI, and DRC. Six groups (group 1-6) shows agreement more than disagreement while group 7 show the opposite. The highest interaction is ARC in overall. The lowest interaction is DRC. Groups that shows DRC is only group 1 and group 7.

In discussion forums, students exchanged thought and ideas to negotiate, debate, and defend their own opinions [24]. It makes sense that should be agreement and disagreement in discussion forums.

4.2 Number of Meaningful Interaction

Group 1 has the highest number of meaningful interaction while the lowest is group 2 (see Figure 6). The difference between highest and lowest is 33. Average number of meaningful interaction is 14. There are three groups that considered high, group 1, group 3, and group 4. While other four groups considered low. Many factors can affects meaningful interaction. This study focused in student-student interaction.

Group 1 has the highest number of meaningful interaction. Many factors affect high of meaningful interactions. Student could meet in online and discussed about topic in small group environment. In small group learning environments, students interact more easily with other students [25] [26] [27]. This is also related to personality of student. Introvert student in offline class may behave as extravert in online discussion [28] It is make higher online participation. Remember that interaction is intertwined with participation [29]. Another factors that may affected is course design. Course design affects interaction [30] and could be foster meaningful interaction [31].

4.3 Trendline of Gain Score and Number of Meaningful Interaction

Type of interaction could be different, so could levels of learning outcomes be. Trendline of N-gain score and number of meaningful interaction leaning left (see figure 7). Regression linear graphic leaning left to right. Equation from N-gain score trendline (1) and number of meaningful interaction (2) is described.

$$y = -3{,}71x + 76{,}43 \quad (1)$$

$$y = -3{,}75x + 29{,}14 \quad (2)$$

Gradient has negative value. Gradient from (1), -3,71, has almost same number with (2), -3,75. It means that n-gain score and number of meaningful interaction have same tendency. Every value of x in (1) should be have same distance with value of x in (2).

This research findings showed correlation between learning outcomes and meaningful interaction. Student discuss topic in three weeks resulted regular interaction with course content. It is inline with study from Morris [32] states that regular interaction with the course content affect learning outcomes. Discussion is an interactive activites which student can share idea and get feedbacks from peer. Many studies have shown that interactive activities is affects learning outcomes [33] [34] [35]. Online learning environment are is the same character as offline environment. Student interaction contribute in high gain score, as indicator of academic success, in student-centered and small groups environment [36]. Students interactions has influence in learning outcomes, this findings inline Quadir [37] which stated that students interaction have a significant influence on objective and subjective learning outcomes.

Peer support in student interaction is a factor in online learning [38] contribute to learning outcomes [39]. Working in small groups related to the role of teamwork. They [40] noted that working groups have a positive impact on learning outcomes of students. Interaction as part of social networks also influences learning outcomes. Sparrowe *et al*. [41] suggested that social networks had a direct impact on the final learning outcomes of learners.

Types of interaction in an online discussion forums can be different, so can levels of cognitive engagement be. It is may influenced by many factors. The variables may include presence, role, and

expectations of lecturer. These variables may clarified as discussion goals, facilitation, and discussion questions, size of the class or course, delivery format, final course score, gender, and maturity of student [24]. It is impossible to suggest guidelines for online discussion or instruction, but it is imperative to realize that multiple factors may influence each other that affect student learning. Lecturer can manipulate factors to promote student learning.

5. Conclusion

The study revealed type of interaction that happened in online discussion forums such as ARA, ARC, ARI, DRA, DRI, and DRC. The highest number of meaningful interaction is 35 from group 1. It is may influenced by many factors. This research results correlation between number of meaningful interaction and learning outcomes in Nuclear Magnetic Spectroscopy topic. Number of meaningful interaction and learning outcomes has same tendency.

The findings cannot be generalized because limited number of students and academic level in this study. Future studies, may recruits large number of students from a other disciplines. This data were far from sufficient to explain relations among variables that affect online learning. Each of type of interaction may has different effects on learning outcomes. Accordingly, further research should specify kinds of interactions and their varying impacts on online discussion, instruction, and learning. It is important to explore how each student has cognitive engagement and learns in an online course. All these are essential to explore and understand but it is well beyond the scope of this study.

Acknowledgement

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