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File size:	759.66K
Page count:	11
Word count:	6,171
Character count:	33,108
Submission date:	19-Jun-2020 12:03PM (UTC+0530)
Submission ID:	1346400066

JPII 9 (2) (2020) X

Jurnal Pendidikan IPA Indonesia

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IDENTIFYING UNDERGRADUATE STUDENTS' MISCONCEPTIONS IN UNDERSTANDING ACID BASE MATERIALS

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DOI: 10.15294/jpii.v9i2.23193

Accepted: January 27th 2020. Approved: Xth 2020. Published: June 30th 2020

ABSTRACT

Students' misconceptions have become phenomenon in teaching and learning, especially in chemistry which is considered as difficult subject. The objective of this study is to identify undergraduate student's misconception profiles related to acid-base concepts in inorganic chemistry. This test was conducted with 15 item three tier multiple choices test. Data were identified descriptively and qualitatively. This test instruments are judged as valid with CVR score of 0,99 and mean of 1,73. Meanwhile, the reliability for this instrument varies for each tier combination; for tier one only, r11 was given reliability score for 0,93; for combination tier one and tier two, r_{12} score was 0,90, and for combination of all tiers, r_{13} score was 0,81. The test conducted revealed that average percentage of misconception in this test is 33.31% for all items. The highest misconception profile is 60,61% in item no.6 hard soft acid base concept. This includes 15,15% misconception false positive, 9,09% misconception false negative, and 36.36% specific misconception.

Keywords: misconception; acid; base; inorganic learning

INTRODUCTION

Chemistry is difficult to learn (Cartrette & Mayo, 2011). There are many reasons for students finding chemistry difficult to learn (Cardelini, 2012). One of the reasons is because Chemistry is complex subject that explores many abstract topics and concepts (Burrows & Mooring, 2015). One other reason is lack of understanding in macroscopic, microscopic, and symbolic perspective in chemistry (Kidanemariam et al., 2013).

Students' success in chemistry courses and particularly in upper level courses depends on prior knowledge and information they have learned in previous courses (Dickmann et al., 2019). Existing constructions that are at odds with accepted science can provide a shaky foundation for new concepts, and there are vast quantities of constructivist research within the science education literature, much of which deals with such incorrectly constructed scientific concepts or misconceptions.

Some past decades, it was assumed that students don't have any preconceptions or knowledge in chemistry (Barke et al., 2011). As students learn about the world around them formally through school education or informally through their everyday experiences, they often tend to form their own views (Gurel et al., 2015). Empirical studies, however, showed that learners have preconceptions for many materials and that these preconceptions don't match today's scientific concepts (Barke et al., 2012). The different form of students understanding and self-constructed conceptions have been called by a number of different terms such as "alternative conceptions" (Hanson, 2019), "Alternative Framework" (Seligin, 2012), "Misconceptions" (Mubarak et al., 2016), "naïve conception" (Lachapelle et al., 2013), "children ideas" (Wee, 2012), "intuitive conceptions" (Lemmer, 2013), "intuitive scien-

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Submission date: 19-Jun-2020 12:03PM (UTC+0530)
Submission ID: 1346400066
File name: S._Mubarak.pdf (759.66K)
Word count: 6171
Character count: 33108

JPII 9 (2) (2020) X

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Some past decades, it was assumed that students don't have any preconceptions or knowledge in chemistry (Barke et al., 2011). As students learn about the world around them formally through school education or informally through their everyday experiences, they often tend to form their own views (Gurel et al., 2015). Empirical studies, however, showed that learners have preconceptions for many materials and that these preconceptions don't match today's scientific concepts (Barke et al., 2012). The different form of students understanding and self-constructed conceptions have been called by a number of different terms such as "alternative conceptions" (Hanson, 2019), "Alternative Framework" (Seligin, 2012), "Misconceptions" (Mubarak et al., 2016), "naïve conception" (Lachapelle et al., 2013), "children ideas" (Wee, 2012), "intuitive conceptions" (Lemmer, 2013), "intuitive scien-

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ce" (Russ et al., 2012), "conceptual difficulties" (Akram et al., 2014), "phenomenological primitives" (Ozdemir, 2013), and "mental models" (Sunyono et al., 2015).

Although some has presented an analysis of the subtle distinctions in the usage of these terms above, no consensus has been reached on the term of choice (Naah & Sanger, 2012). For simplicity, the term of misconceptions will be used in this study and it means any concept that differs from the commonly accepted scientific understanding of the term. Misconception is used when referring to students' incompatible ideas with scientific views (Arslan et al., 2012). Everyone can experience misconception (Suprapto, 2020) including students. Many sources of students' misconceptions have been identified, including: everyday experience (Daud et al., 2015; Wee, 2012), instructional language and terminology (Akram et al., 2014; Chrzanowski et al., 2018), textbook (Zajkov et al., 2017), teachers (Yates & Marek, 2014) and even the internet (Sesen, 2010). Misconception is a real factor that can affect student failure in academics (Sofianto et al., 2020).

In teaching process, teacher should be able to distinguish student who can understand the concept well, less understand, not understand and have misconception or mixture of alternative conception so then later we can prevent the problem correctly (Mubarak et al., 2016). Student who held misconception will have difficulties in accepting new concept and knowledge (Yangin et al., 2014). False concept and knowledge that has been strongly held by student will be considering as a true concept, then they will apply those concept that they think right into the new concept they accepted. Later, students' misconception will be difficult to eliminate (Daud et al, 2015).

Acid-base is of the difficult and major material in chemistry, including in inorganic chemistry. Study has shown high possibility to retain misconceptions in students as well as concept related to acid base chemistry such as neutralization (Cokelez, 2010), pH (Kala et al., 2013), and buffers and buffers problems. Most of preliminary study was conducted to understand high school student (Amalia et al., 2018; Chakraborty & Mondal, 2012; Cokelez, 2010; Mubarak et al., 2016) or teacher (Duran & Usak, 2015) conception profiles in acid base materials or in other context such Organic chemistry (Cartrette & Mayo, 2011). Since there is no specific report and study about misconception held by undergraduate student in understanding inorganic chemistry acid base materials, it becomes important to understand undergraduate student conception profiles in understanding acid base materials in Inorganic chemistry so then later we can prevent the problem correctly.

To identify student misconceptions, we can use three tier multiple choices since it is the most common diagnostic test for identifying student science misconceptions (Soeharto et al., 2019). Basic principle for this diagnostic test is considering that student already held some understanding in science concepts that had been taught (Sesli & Kara, 2012). Three tier tests are considered to be more accurately eliciting the student misconceptions, since they can detect lack of knowledge percentages by means of the confidence tiers. (Gurel et al., 2015). So then, the purpose of this study is to describe undergraduate chemistry students' conception profiles in understanding acid base materials at inorganic chemistry subject by using acid base diagnostic tests (ABDT), a three-tier multiple choice diagnostic test to identify.

METHODS

Research conducted in Islamic State University of Mataram (UIN Mataram). Thirty-three undergraduate students and also prospective teachers at second year who enlisted in Inorganic Chemistry class and have involved in basic chemistry courses became the subject of this research. The method of the research is descriptive qualitative, and to obtain data about student conception profiles it was using acid base diagnostic test (ABDT), a three-tier multiple choice diagnostic test.

Each item test in ABDT consisted of three tiers. First tier is answer tier, a multiple choice with five options, one is for the correct answer and four others are distractors. Second tier is reasoning tier, a multiple choice with five options, one is for the correct reason and four others are distractors. The last tier is certainty level tier, a five-scale range for certainty starts from 1 as just guessing, 2 as really uncertain, 3 as uncertain, 4 as certain and 5 as really certain. This certainty of response index (CRI) can tell us about how much that the students certain about their answer and we can decide either the students held misconceptions or do not know the concept at all (Siswaningsih et al., 2019).

ABDT consists of 15 item tests composed of acid base theory, nature of acid base solution, Lewis acid base concept, intermolecular forces, hard and soft acid base concept, and super acid and super base concept. The blue-print of ABDT

item test displayed in table 1. Students' answers to each item were considered correct when both the correct choice and reason are given with a high confidence. Similarly, students' answers were considered as misconceptions when a wrong answer choice is selected with an accompanied wrong reasoning and with a high confidence.

Table 1. The Blue-print of ABDT

Material	Learning Goal	Number of Test Item
Arhenius concept	Understanding classic concept of acid base and how to apply it	1, 8
Bronsted Lowry concept	Understanding acid base strength and non-aqueous solvent	2, 9, 15
Lewis Acid Base Concept	Understanding Frontier orbital and acid base reactions and term of frustrated Lewis pair	3,4,10,11
Intermolecular forces	Understanding effect of hydrogen bonding in acid base concept	5, 12
Hard soft acid base (HSAB)	Understanding concept of hard soft acid base (HSAB) and its application	6,13
Super acid and super base	Understanding term of super acid and super base	7, 14

Student responses then analyzed and interpreted to understand misconceptions held by students. Each student will give unique characteristic of misconception they held, this helps the test users such that the obtained percentage of misconception is free from false positives, false negatives, and lack of knowledge, since each requires a different remediation and treatment.

Data collection that used in this research including documentation, interview, survey, and test. Interview conducted to collecting information about the instrument that being develop and in post conducted test researcher find that some student leaved the reasoning section remain blank. However, by conducting the interviews, it found that some of them had a good reasoning ability. The interview itself was constructed by cognitive interview approach which intended to evaluate, and to improve self-report questions and measurement instrument (Willis, 2015). By conducting diagnostic interview, reason from misconception on students' answer can be analyzed deeply (Sadhu et al., 2017). Questionnaires shared among student to understand their responses after doing the test. The result of this study presented as descriptive narrative form since the narrative text has been the most frequent form of displaying the qualitative data (Creswell & Creswell, 2017).

Data analysis for this research including validity, reliability of the instrument, level of difficulties and discriminating power, questionnaires analysis, interpretation of three tier multiple choice response and student conception profile analysis. The validity for this instrument is measured by Content Validity Ratio (CVR). Content validity represents one of the validation kinds and can provide information about the representativeness and clarity of each item on the instrument (Medeiros et al., 2015). CVR is an approach of content validity to determine the suitability of the item with the measured domain by expert judgment. It is highly recommended to apply content validity while the new instrument is developed (Taherdoost, 2016). This validation step involves 5 experts. Content validity is essential examination to know whether the skill of reasoning chemistry reasoning ability and contained and given what is being measured in the integrated assessment instrument (Sadhu et al., 2019). The product is stated as valid by expert validators by CVR score of 0,99 and mean score of 1,73 which has met the valid instrument criteria. This means that the item test has been suited with acid base materials in inorganic chemistry courses for second year university students.

The reliability measure by KR_{20} formula as applied by Mubarak et al. (2016). The measurement of reliability was using combination of each tier. Reliability for $tier_1$, r_{11} score was 0,93, for combination $tier_{1\&2}$, r_{11} score was 0,90, and for combination of all $tiers_{1,2,\&\ 3}$ r_{11} score was 0,81. This decreasing scores in reliability is in line with the finding of Dehnad et al. (2014) study which finds that when the number of option increases, the number of reliability decreases. The reliability will be accepted if r_{11} score > 0,70, which means this instrument is reliable and this instrument is good in revealing student misconception in inor-

ganic chemistry acid base materials since all tier combination have higher score than 0,70.

Besides the instrument must be valid and reliable, the instrument must have a good level of difficulties and discriminating power. The level of difficulties and discriminating power were measured by varying the combination of all tiers. Level of Difficulties of item test vary in scale from 0,32 – 0,72 this means that ABDT was on moderate difficulty. Good diagnostic test is instrument with moderate difficulties (Mubarak et al., 2016). Fariyani et al. (2015) also choosing moderate difficulties item for diagnostic test. The discriminating power score vary from 0,21 – 0,56, this means that the ABDT had proper ability to discriminate student ability in completing the test.

Figure 1 shows how the combination of tier will affect the item difficulty in test, number of test item slightly increase to more difficult level as the number of tier increase.

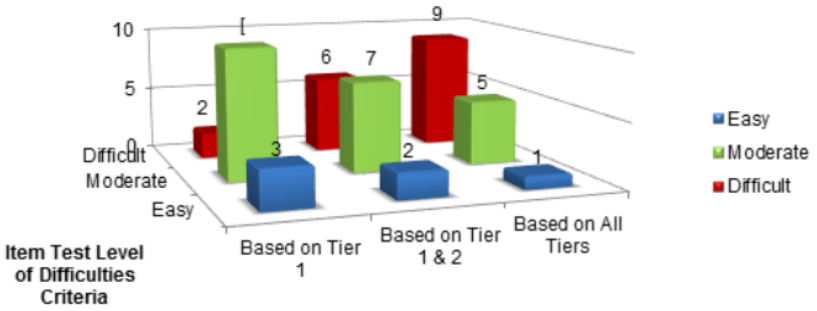

Figure 1. Comparison Test Item Level of Difficulties based on All Tiers Combination

In figure 1, item tests are getting more difficult by addition of tier combination. This shows that student getting more difficult in doing the item test. This in line with the result studied by Dehnad et al. (2014) that stated increasing the number of options also contribute in increasing the item difficulty in test.

Figure 2 shows that for different combination tiers give different characteristic on item discrimination, which increasing number of tiers and options also contribute in increasing item discrimination ability.

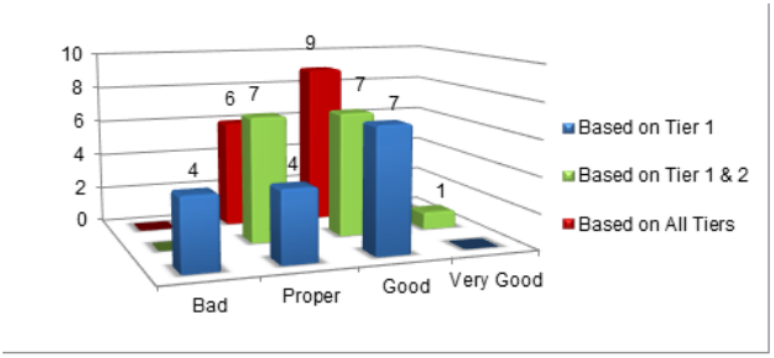

Figure 2. Comparison Test Item Discriminating Power based on All Tiers Combination

In figure 2, the ability of test item in distinguishing high-level performance students with low-level performance student is getting better along with tier addition in instrument. Those two figures show to us, despite the test item being more difficult, but it gave us a better perspective to distinguish students' ability in understanding the material. This happens especially because of addition of CRI, since the nature of the CRI is usually to distinguish students' error and misconceptions (Mukmin & Fa'ani, 2019).

Interpretation of three tier multiple choice response classified by answer combination pattern introduced by Arslan et al. (2012) as shown in Table 2. Certainty level is considering at high level if students choose 4 or 5 out of 5 scale and considering at low level if choose 3 or below out of 5 scale.

Table 2. All Possibilities of Responses

Answer patterns			Categories
Tier 1	Tier 2	Tier 3	
Correct	Correct	Certain	Scientific knowledge
Correct	Incorect	Certain	Misconception (False+)
Incorect	Correct	Certain	Misconception (False-)
Incorect	Incorect	Certain	Misconception
Correct	Correct	Uncertain	Lucky guess/lack of confidence
Correct	Incorect	Uncertain	Lack of Knowledge
Incorect	Correct	Uncertain	Lack of Knowledge
Incorect	Incorect	Uncertain	Lack of Knowledge

Scientific knowledge (SK) is condition where students' responses show the condition that includes all component of the validated respons (Arslan et al., 2012) and an ability to unify and think all constituent entities, their structural relations and interaction in a holistic and systemic manner (Tümay, 2016). This contribute to an interrelated network of laws, theories, and concept.

Misconception (false positive) (MF+) is a condition which student show a correct response with poor reasoning ability. Bayrak (2013) stated that this type of misconception indicates their learning is not meaningful learning, but superficial and rote learning. In some of the questions, students know the correct answers, but they do not have any idea why these are correct.

Misconception (false negative) (MF–) is a condition which student show a correct reasoning with false concept. This type of misconception happens because student carelessness (Syahrul & Setyarsih, 2015) or inattention in choosing test answer (Kibble et al., 2012). In three tier test evaluation, content validity is additionally affirmed by calculating the percentage of false negative, it is recommended that the percentage of false negative should not exceed 10% (Arslan et al., 2012; Peşman & Eryilmaz, 2010).

Specific misconception (M) is condition which students show alternative conception that different with expert. This type of misconception indicated by their incorrect responses in both first and second tiers and having a high confidence level (Arslan et al., 2012). This is also an indication of *Dunning-Kruger effect* that individual who are unsuccessful at a task lacks the metacognitive skills that enable them to recognize their poor performance (Brandriet & Bretz, 2014a).

Lack of confidence (LC) is a condition which students show a correct response, but just lack in confidence level (Mubarak et al, 2016) or denoting uncertainty at CRI (Taslidere, 2016). Students probably could not construct clear understanding since they had just learned the subject for the first time (Korur, 2015). Meanwhile, lucky guess (LG) is condition which the students show correct responses but they choose just guessing as their option in CRI (Mubarak et al., 2016). Students in this case may have pseudo think indication that they can express the scientific concept with scientific reason just by their gut feeling and guess.

Lack of knowledge (LK) is condition of being uncertain regardless of correct or incorrect responses to first and second tiers with a low certainty response index value indicate guessing. (Arslan et al., 2012). This low confidence case suggests they were aware that they were performing poorly or were possibly guessing (Brandriet & Bretz, 2014b), and therefore, had no understanding, or were confused about their understanding (Anderson & Clark, 2012).

RESULTS AND DISCUSSION

Student misconceptions profiles in acid base in inorganic context is consider as high. Average percentage for all type misconceptions in this test is 33.13% for all items (see table 3).

Table 3. Student Conception Profiles in Acid Base Three Tier Multiple Choices Diagnostic Test

Number of Item Test	Conception Profiles (%)						Total (%)
	SK	MF+	MF–	M	LG/LC	LK	
Q1	30,30	9,09	6,06	36,36	3,03	15,15	100
Q2	15,15	3,03	0,00	42,42	9,09	30,30	100
Q3	18,18	15,15	18,18	24,24	6,06	18,18	100
Q4	15,15	0,00	3,03	48,48	9,09	24,24	100
Q5	18,18	12,12	6,06	15,15	9,09	39,39	100
Q6	18,18	15,15	9,09	36,36	3,03	18,18	100
Q7	45,45	0,00	3,03	6,06	18,18	27,27	100
Q8	36,36	0,00	6,06	9,09	30,30	15,15	100
Q9	78,79	0,00	0,00	12,12	6,06	3,03	100
Q10	33,33	3,03	0,00	21,21	21,21	21,21	100
Q11	39,39	3,03	0,00	30,30	15,15	12,12	100
Q12	6,06	3,03	0,00	33,33	6,06	51,52	100
Q13	21,21	0,00	0,00	27,27	21,21	30,30	100
Q14	52,52	0,00	0,00	3,03	33,33	12,12	100
Q15	18,18	0,00	3,03	30,30	27,27	21,21	100
Mean	29,70	4,44	3,63	25,05	14,55	22,63	100

Highest misconception profile is 60,61% in item no.6 hard soft acid base concept. This includes 15,15% MF+, 9,09% MF–, and 36.36% M. This high percentage of misconceptions held by students caused by their confusion in understanding HSAB concept. Only 18,18% students are in SK category and the rest divided into LG/LC and LK. See figure 3 for test item questions.

6. Consider the concept of hard and soft acids and bases in determining your answer on the first tier and reason on the second tier.

For the questions below, Give an (X) mark on the correct answer.

6.1. Using hard–soft concepts, which of the following reactions are predicted to have an equilibrium constant greater than 1? assume gas-phase or hydrocarbon solution and 25°C.

A. $R_3PBBr_3 + R_3NBF_3 \rightleftharpoons R_3PRF_3 + R_3NBBr_3$
B. $SO_2 + (C_6H_5)_3PHOC(CH_3)_3 \rightleftharpoons (C_6H5)_3PSO_2 + HOC(CH_3)_3$
C. $CH_3HgI + HCl \rightleftharpoons CH_3HgCl + HI$
D. $[AgCl_2]^-_{(aq)} + 2CN^-_{(aq)} \rightleftharpoons [Ag(CN)_2]^-_{(aq)} + 2Cl^-_{(aq)}$
E. $Pb(NO_3)_{2(aq)} + MgI_{2(aq)} \rightleftharpoons PbI_{2(aq)} + Mg(NO_3)_{2(aq)}$

6.2. The following reasons that support your answer above are:

A. Phosphines are softer bases than amines. While the BBr_3 is a softer Lewis acid than BF_3, a consequence of the relative hardness and softness of the respective halogen substituents. Therefore, the equilibrium position for this reaction will lie to the left, the side with the soft-soft and hard-hard complexes, so the equilibrium constant is greater than 1
B. Cyanide is a softer and generally stronger base than chloride. Therefore, cyanide will displace the relatively harder base from the soft Lewis acid Ag^+. The equilibrium constant is greater than 1
C. Iodide is a softer base than chloride, the soft acid CH_3Hg^- will form a stronger complex with iodide than with chloride, whereas the hard acid will prefer chloride, the harder base. Thus, the equilibrium constant is greater than 1.
D. The soft Lewis acid sulfur dioxide displaces the hard acid /-butyl alcohol from the soft base triphenylphosphine. The soft-soft complex is favored, so the equilibrium constant is less than 1.
E. Pb^{2+} ion and I^- ion are hard-hard pairs, while Mg^{2+} ion and NO_3^- ion are soft pairs so the equilibrium constant is greater than 1.

6.3. How certain are you with the answers and reasons you give?

1. Just guesing 2. Very uncertain 3. Uncertain 4. Certain 5. Very certain

Figure 3. Item Test Number 6 about HSAB Concept

We can see student pattern in answering item no. 6 about HSAB concept in figure 4, which shows how student responses the question and how their certainty level in that response.

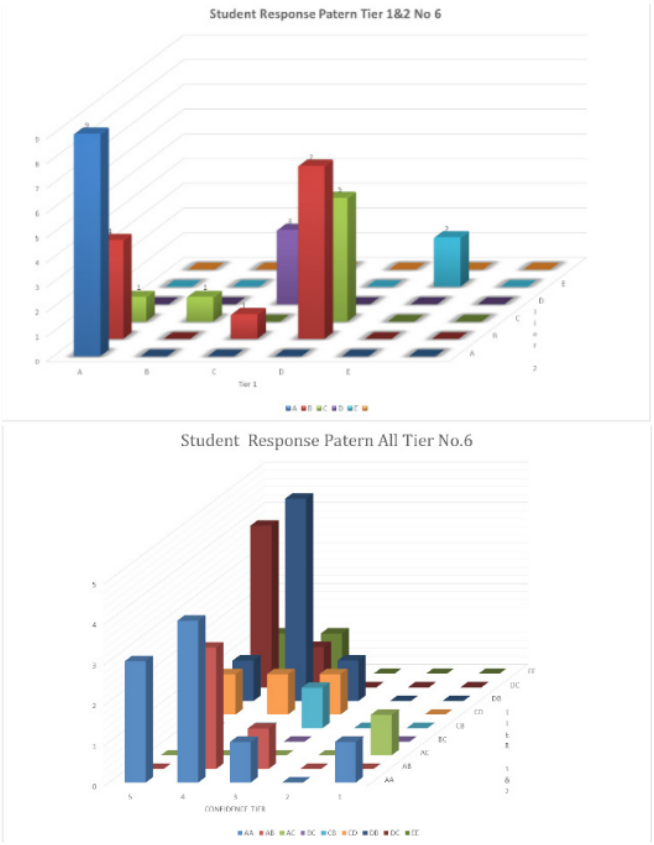

Figure 4. Students' Responses Pattern in All Tier For Item Number 6

In Figure 4, we can see mostly students who held misconception trapped by their prior knowledge about strong weak acid base concept and give high certainty about their answer. Meanwhile, some students were able to choose a correct response for the HSAB concept but they cannot give a correct reasoning for the concept. This can happen because the HSAB concept is still new concept for them. This type of case happening because in understanding new concept student tend to mix their prior knowledge with new concept they accepted. The difficulties faced by students are considered as high since to give correct response to this item need at least three prior knowledge to understand by them such as chemical equilibrium, naming the ions and acid base concept. In that case, students' chemistry misconceptions about an emergent property may not derive from a failure to understand isolated entities, their properties, and interactions or the parameter of the entities but from failure to think all constituent entities, their structural relation and interactions in a holistic and systemic manner (Tümay, 2016) which later will affect their learning process.

Second highest misconception profile is 57,58% for item no.3. in Lewis acid base concept. This include 15,15% MF+, 18,18% MF–, and 24.24% M (see table 4).

Table 4. Students' Response Combination Pattern in Item Number 3.

Item Number	Conception Profile	Subject (%)	Student answer combination pattern
Q3	SK	18,18	(A-A-5); (A-A-4)
	MF+	15,15	(A-B-5); (A-C-4)
	MF-	18,18	(B-A-5); (B-A-4); (D-A-4)
	M	24,24	(B-B-5); (B-B-4); (B-C-4); (C-C-4); (E-E-4)
	LG/LC	6,06	(A-A-3)
	LK	18,18	(A-C-3); (B-A-3); (B-B-3); (B-B-2); (B-D-3); (E-B-5)

This item was asking about Lewis acid base concept in reaction of $BrF_3 + F^- \rightarrow BrF_4^-$, most of students (33,3%) think that students in this context reasoning that F^- ion only containing with one electron as if in e^- which actually F^- ion act as pair electron donor. They are failed to think the configuration of ion microscopically that's why they mostly think that this type of reaction is Bronsted concept for acid base rather than Lewis acid base concept.

In interview after the test, it was made sure that it was strongly a misconception, at this diagnostic interview student tends to defend their opinion and still believe that what they give in test was the correct responses. As example when student asked about why they think that F^- ion is the same one as e^- because in their personal representative of an F^- ion is ignoring the fact that F^- ion consisted of eight electrons, which means they are lack in the microscopic aspect of chemistry. It is important to emphasize to student the three level of chemistry representation, so that student will have a better conceptual understanding. It is needed some concern since no matter how small the differences are from scientific conceptions, the label is misconception (Nilsson & Niedderer, 2014).

There is positive and significant correlation between first and second tier corelate with their certainty level (figure 5., r=0,67 n=33, p<000).

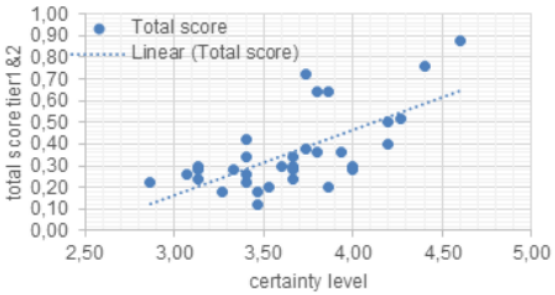

Figure 5. Two Tier Score Vs Certainty Level Scatter-Gram

This means that students with high score on first and second tier also have high confidence in their certainty level. The similar report also found in prior research by Peşman & Eryilmaz, (2010) and Mubarak et al. (2016) that shows positive and significant correlation between student scores and their certainty level. But some interesting issue that we can see in figure 5 is that students with high certainty level also are dominated by student with low score for $tier_{1\&2}$ which indicate potential misconception to be occurred (Peşman & Eryilmaz, 2010), either that MF+, MF- or M type of misconceptions. It is recommended that the percentage of false negative should not exceed 10% (Arslan et al., 2012; Peşman & Eryilmaz, 2010). In this study the obtained percentage of false negative is 3,63% and false positive is 4,44%, which are in recommended values.

This finding shows some interesting aspect about student self-efficacy in their decision to choose the answer, reason and certainty level they give. Average percentage for lack of confidence in this test is 14.55% for all items. This low confidence case suggests they were aware that

they were performing poorly or were possibly guessing (Brandriet & Bretz, 2014b). Determining the conceptual understanding level of students can be considered to be the first step of a longitudinal study aiming to promote the engagement of students in learning process (Saricayir et al., 2016).

CONCLUSION

Subject of acid base has important role in chemistry education. Concept of acid and base in chemistry are interrelated (Bayrak, 2013) when students have difficulties in understanding this concept, they will experience difficulties in other related chemistry subject. In that case, students' chemical misconceptions about an emergent property may not derive from a failure to understand isolated entities, their properties and interactions or the parameter of the entities but from failure to think all constituent entities, their structural relation and interactions in a holistic and systemic manner (Tümay, 2016) which later will affect their learning process.

Finally, the result of this study clearly shows that a number of students did not acquire a satisfactory understanding of several acid base chemistry concepts, including acid base theory, strong weak acid base concept, hard soft acid base concept and dissociation of strong and weak acid base. It is important for us to understand that this result also comes from students' prior knowledge, which they learn in their senior high school. So, strengthening their understanding of acid base concept in early stage will be very helpful and then in higher level should emphasize on how they adapt with the new concept that they learn. It is also important for emphasizing the role of chemistry representation in building holistic chemistry conceptual understanding since discovering, identifying, changing the misconception in chemistry is difficult and challenging for us as it our responsibilities as an educators to be aware of students' conception.

By adding certainty tiers to the items, the evidence emerged that students were generally unaware of what they do not know. It is important for us to improve our way to maximize the meaningful learning for students and acknowledge how students' intention in making decision in their answers and tackles their carelessness in solving the problems. Since we can measure student certainty and correlate that with their self-efficacy is important for next researchers to identify the effect and impact of metacognition in overcoming student misconceptions profiles.

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