The map of post-5th semester pre-service chemistry teachers’ conceptions at universitas negeri surabaya

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Abstract. This study aims to map the conception of pre-service chemistry teachers individually and in groups. The participants were 88 post-5th semester pre-service chemistry teachers at Universitas Negeri Surabaya (Unesa). Mapping conceptions of the participants used three tier diagnostic tests which is administered into the Ionunesa Detector software. The study found every participant has a burden (percentage) of misconceptions on chemical subject matter will be taught at school. In addition, there were four subject matters tested (chemical bonding, solution, reaction rate, and chemical equilibrium) in which the misconceptions burden of participants for the subjects were above 27% and the highest burden occurred in chemical bonding, the amount of 45.99%.

1. Introduction
The phenomenon of chemical misconceptions in teachers is a common thing. Chiu [1] and Taber [2] reported there were chemistry teachers with misconceptions in the schools. Kolumuc and Tekin [3] found the phenomenon in Turkey, then Burgoon et al. [4] faced it in the United States. Chemical misconceptions in the chemistry teachers also occurred in Indonesia [5]. According to Chiu [1], when teachers experience misconceptions, students tend to experience misconceptions as well, because teachers become one of the references of knowledge for students. Taber [2] perceived that chemical misconceptions in students occur due to chemical learning processes designed and implemented by teachers who had misconceptions. Lemma [6] had proven what Chiu and Taber stated. Lemma found a significant correlation between the intensity of chemical misconceptions in students and their teachers with a determination index of 90%. It meant that the misconception occurring in students was 90% caused by teachers’ misconceptions, while 10% is due to other factors.

Educational universities in Indonesia producing teachers must participate in limiting the existence of teachers with misconceptions. The educational universities intervention into schooling is certainly not easy. The only feasible way of participating to be taken is through substitution. The substitution method certainly cannot be done instantly. The universities can prepare the substitution method through the stages of (1) mapping the conception status and individual characteristics causing misconceptions, (2) developing conceptual change models/strategies, (3) developing supporting tools for implementing conceptual change strategies, and (4) implementing of conceptual change strategies to reduce individual misconceptions.

On this occasion, the research was limited to the results of mapping the conception status of post-5th semester students at Chemistry Department Unesa as pre-service chemistry teachers. The students had completed lectures that facilitated an understanding of basic chemical concepts. The students still have the opportunity to revise their conceptions through clinical services provided by the department.
The results of the mapping are then used as the basis to design the four stages for preparing pre-service chemistry teachers as mentioned before.

2. Research method
The conception map was a table representing the status of each individual target group and histogram representing a representation of “knowing concept (KC),” "not knowing concept (NKC),” “error (E),” and “misconceptions (MC)” in each of the concepts tested. For example, percentage of MC was the number of misconceptions occurring on each topic divided by the total number of students tested (n) multiplied by the number of items the concept was tested. It was likewise the calculation of KC, NKC, and E. This representation was used because that in fact on each subject matter (which consists of a number of concepts), there was always a question item (representation of a particular concept) that was understood as a misconception by students.

The concepts being tested is limited to four subject matters, namely chemical bonding, solution, reaction rate, and chemical equilibrium. The participants were 88 chemistry students who passed 5th semester in Unesa. The tool to map the students’ conceptions, namely, three tier diagnostic tests of chemical concepts on the four subject matters. The test was validated both theoretically (construct and content validity through experts’ judgments) and empirically (trials). The three tier diagnostic test was administered into the software called Ionunesa Detector.

3. Results and discussion
There are two findings discussed to describe pre-service chemistry teachers’ conceptions, that are, (1) mapping individual conceptions and (2) mapping group conceptions. The two will be elaborated below in more detail.

3.1. Mapping Individual Conceptions on Four Chemical Topics
The map of individual conceptions of the participants was presented in Appendix A. It appears that each individual had a burden (percentage) of misconception on the four topics tested, and even found individuals who have a greater percentage of MC than the status of other conception (KC and NKC). It found that only 3 students (3.41%), 2 students (2.27%), 5 students (5.68%), and 5 students (5.68%) were free of MC. The four chemical subject matters contain chemical concepts that will be taught at school. Individuals who were known to be free from the MC cannot be understood as 100% KC, but it was not in the NKC status. No students was found who knew the concept in all the items of the concept tested. The condition was far from ideal when they want to be substituted for the existence of chemistry teachers with misconceptions in schools. The educational universities producing pre-service chemistry teachers must take preventive actions by preparing pre-service chemistry teachers with poor misconceptions, so that they will not contribute to increase the number of MC teachers in the schools.

The distribution of status of individual conceptions varies with different chemistry subject matter. In the same chemistry subject matter, the distribution of the status of one individual's conception was different from another individual. It is because the conceptions cannot be separated from the concepts itself [7]. The concept is given and objective, while the conception is the transformation of the given and objective, belonging to people. In other words, the conception is subjective [8]. Therefore, in order to design preventive actions on MC, the educators or researchers have to consider individual characteristics and be treated individually as well.

3.2. Mapping Group Conceptions on Four Chemical Topics
The map of group conceptions of pre-service chemistry teachers Unesa on four topics, namely chemical bonding, solution, reaction rate and chemical equilibrium is presented in Figure 1.
The group conception map has the following meanings: (1) only the reaction rate subject matter had the percentage of KC exceeding the other percentage of conception status (NKC, MC, and E), (2) on three other subject matters (chemical bonding, solution, and chemical equilibrium), the percentage of NKC and MC were greater than KC, and (3) in the four subject matters tested, it was found the percentage of MC was above 27% and the highest was 45.99% occurring on the chemical bonding subject matter.

Based on the data in the Figure 1, None of the participants understood completely (KC) chemical concepts that had been studied before. NKC, E, and MC have been still coloring the domain of understanding of the participants. In other words, the pre-service chemistry teachers have been still carrying the burden of misconceptions. As a common, understanding concepts is achieved through information processing [9]. Conceptions stored in working memory are determined by individual perceptions and coding of information received through sensory memory, as well as acceptability in the structure of long-term memory [7]. In a learning, there can be "coercion" of information to enter into long-term memory, so that the students do not get meaningfulness in learning. As a result, even though they have gained concept, they have been in NKC, E, and MC status. According to Suyono and Hariyanto [7], learning that does not facilitate the establishment of relationships between students’ prior-knowledge and new information can interfere two important processes of concept development, namely assimilation and accommodation. The success of assimilation and accommodation is influenced by the success of interactions and interconnections between new information (facts, data, events) and the schemes that exist in one's brain. Interconnection is influenced by how a person responds to stimuli that enter sensory memory, which is then processed in short-term memory and then stored in long-term memory.

4. Conclusion

Based on the results of the analysis and discussion can be summarized as follows:

1. Each individual had a burden (percentage) of misconceptions on the four subject matters tested, and even it found individuals who have a greater percentage of MC than other status of conceptions (KC and NKC).
2. Only in one subject matter, the reaction rate, the percentage of KC exceeded the percentage of other conception status (NKC, MC, and E). The chemical bonding, solution, and chemical
equilibrium subject matter contained a greater percentage of NKC and MC than KC. in the
four subject matters tested, it was found the percentage of MC was above 27% and the highest
was 45.99% occuring on the chemical bonding subject matter.
3. There was no participant having completely understood the chemical concepts. It because of
the lack of accommodating efforts to facilitate the success of the assimilation and
accommodation process.

References
[1] Chiu M H 2005 Chem. Educ. Inter. 6 1-8
[2] Taber K S 2009 Educ. Quimicia EduQ 4 13-20
[3] Kolomuc A and Tekin S 2011 J. Phys. Chem. Educ. 3 84-101
[4] Burgoon J N, Heddele M L and Duran E 2011 J. Sci. Teach. Educ. 21 859-872
[5] Suyono Yuanita L and Rohmawati L 2012 J. Penelit. Pendidik. Mat. Sains 19 2
[6] Lemma A 2013 Afr. J. Chem. Educ. 3 39-59
[7] Suyono and Hariyanto 2011 Belajar dan Pembelajaran Teori dan Konsep Dasar (Bandung: PT
Remaja Rosda)
[8] Vosniadou S 2013 Conceptual change research: an introduction (New York: Routledge)
[9] Santyasa W 2007 Model-Model Pembelajaran Inovatif Presented in a workshop of action
research for high school teachers in Nusa Penida, 29th June-1st July 2007

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### Appendix A
Percentage of Pre-Service Chemistry Teachers’ Conceptions in Four Chemistry Subject matters

| No | Chemical Bonding | Solution | Reaction Rate | Chemical Equilibrium |
|----|------------------|----------|---------------|----------------------|
|    | %KC  | %NKC  | %MC  | %E  | %KC  | %NKC  | %MC  | %E  | %KC  | %NKC  | %MC  | %E  | %KC  | %NKC  | %MC  | %E  |
| 1  | 5    | 42    | 42    | 11   | 33   | 33    | 29    | 4    | 25   | 25    | 40   | 10   | 15   | 40    | 35   | 10  |
| 2  | 5    | 11    | 68    | 16   | 29   | 13    | 46    | 13   | 30   | 5     | 50   | 15   | 10   | 40    | 40   | 10  |
| 3  | 0    | 21    | 47    | 32   | 38   | 0     | 50    | 13   | 35   | 15    | 45   | 5    | 20   | 5     | 60   | 15  |
| 4  | 5    | 5     | 74    | 16   | 25   | 0     | 58    | 17   | 20   | 5     | 70   | 5    | 15   | 5     | 70   | 10  |
| 5  | 16   | 42    | 32    | 11   | 25   | 29    | 46    | 0    | 45   | 25    | 30   | 0    | 10   | 35    | 45   | 10  |
| 6  | 11   | 58    | 26    | 5    | 17   | 42    | 38    | 4    | 45   | 35    | 20   | 0    | 20   | 60    | 15   | 5   |
| 7  | 16   | 32    | 37    | 16   | 29   | 21    | 33    | 17   | 25   | 65    | 10   | 0    | 10   | 75    | 15   | 0   |
| 8  | 5    | 11    | 68    | 16   | 33   | 4     | 54    | 8    | 60   | 5     | 30   | 5    | 45   | 10    | 40   | 5   |
| 9  | 16   | 42    | 37    | 5    | 17   | 38    | 38    | 8    | 45   | 20    | 30   | 5    | 25   | 25    | 45   | 5   |
| 10 | 16   | 11    | 58    | 16   | 38   | 8     | 50    | 4    | 60   | 5     | 35   | 0    | 50   | 20    | 25   | 5   |
| 11 | 26   | 5     | 42    | 26   | 13   | 4     | 75    | 8    | 60   | 10    | 25   | 5    | 40   | 10    | 45   | 5   |
| 12 | 0    | 47    | 47    | 5    | 46   | 0     | 46    | 8    | 50   | 0     | 40   | 10   | 15   | 20    | 50   | 15  |
| 13 | 21   | 0     | 68    | 11   | 42   | 0     | 54    | 4    | 70   | 0     | 25   | 5    | 60   | 10    | 30   | 0   |
| 14 | 0    | 53    | 32    | 16   | 25   | 42    | 29    | 4    | 60   | 30    | 10   | 0    | 0    | 90    | 10   | 0   |
| 15 | 16   | 5     | 68    | 11   | 17   | 4     | 79    | 0    | 55   | 10    | 25   | 10   | 40   | 15    | 30   | 15  |
| 16 | 11   | 21    | 53    | 16   | 29   | 29    | 42    | 0    | 55   | 25    | 20   | 0    | 15   | 60    | 15   | 10  |
| 17 | 32   | 16    | 47    | 5    | 25   | 13    | 50    | 13   | 60   | 5     | 30   | 5    | 40   | 20    | 35   | 5   |
| 18 | 16   | 26    | 47    | 11   | 21   | 33    | 38    | 8    | 45   | 35    | 20   | 0    | 25   | 40    | 20   | 15  |
| 19 | 21   | 26    | 42    | 11   | 25   | 13    | 58    | 4    | 75   | 10    | 15   | 0    | 45   | 15    | 25   | 15  |
| 20 | 21   | 32    | 42    | 5    | 42   | 8     | 50    | 0    | 70   | 0     | 20   | 10   | 55   | 20    | 15   | 10  |
| 21 | 0    | 74    | 26    | 0    | 13   | 67    | 21    | 0    | 25   | 40    | 35   | 0    | 5    | 75    | 15   | 5   |
| No | Chemical Bonding | Solution | Reaction Rate | Chemical Equilibrium |
|----|------------------|----------|---------------|----------------------|
|    | %KC %NKC %MC %E  | %KC %NKC | %KC %MC %E    | %KC %NKC %MC %E     |
| 22 | 0 79 11 17       | 63 21 0  | 30 40 30 0    | 25 55 15 5          |
| 23 | 16 42 26 33      | 29 38 0  | 50 35 15 0    | 45 35 15 5          |
| 24 | 26 0 58 16       | 33 4    | 54 8 60 5     | 30 5 40 5           |
| 25 | 5 37 53 5        | 17 38 4 | 50 15 25 10   | 35 35 30 0          |
| 26 | 16 11 47 26      | 17 21   | 54 8 55 5     | 35 25 35 5          |
| 27 | 5 74 21 0        | 71 25 4 | 15 70 15 0    | 20 75 0 5           |
| 28 | 21 16 32 42      | 8 50 0  | 75 5 20 0     | 50 10 40 0          |
| 29 | 32 0 58 11       | 42 0    | 50 8 50 5     | 35 10 30 10         |
| 30 | 16 21 37 26      | 13 21   | 63 4 35 20    | 30 15 20 30         |
| 31 | 26 0 58 16       | 25 29   | 38 8 55 10    | 35 10 40 15         |
| 32 | 0 100 0 17       | 75 8    | 0 10 90 0     | 0 0 100 0           |
| 33 | 11 21 53 16      | 29 33   | 33 4 55 25    | 20 0 15 60          |
| 34 | 11 32 32 26      | 29 42   | 29 0 85 5     | 10 0 45 40          |
| 35 | 32 0 58 25       | 11 29   | 42 4 50 5     | 35 10 50 5          |
| 36 | 26 16 26 26      | 29 21   | 42 8 65 15    | 20 0 50 25          |
| 37 | 26 11 42 21      | 25 38   | 33 4 75 10    | 15 0 50 15          |
| 38 | 26 0 58 16       | 17 25   | 46 13 40 5    | 30 5 50 15          |
| 39 | 5 53 26 16       | 29 17   | 50 4 60 25    | 15 0 30 50          |
| 40 | 11 47 32 11      | 25 38   | 29 8 25 40    | 30 5 10 60          |
| 41 | 16 16 47 21      | 29 8    | 50 13 70 10   | 20 0 45 15          |
| 42 | 5 42 47 5        | 21 33   | 38 8 55 20    | 25 0 35 20          |
| 43 | 16 16 53 16      | 25 29   | 46 0 65 15    | 15 5 45 25          |
|    |                  |          |               | 30 0                |
| No | Reaction Rate | Chemical Equilibrium | Solution |
|----|---------------|----------------------|----------|
|    | %NKC %E %KC %MC | %NKC %E %KC %MC | %NKC %E %KC %MC |
| 44 | 11 47 32 11 46 0 46 8 40 25 20 15 10 5 75 10 | 45 5 68 21 5 21 46 29 4 55 40 5 0 20 65 15 0 | 46 32 0 53 16 42 17 42 0 80 0 15 5 45 45 10 0 |
| 47 | 5 47 37 11 21 42 33 4 70 10 70 10 0 20 0 0 35 30 30 5 | 48 16 21 21 21 38 29 0 39 8 66 20 10 5 45 45 5 5 45 70 25 20 10 0 |
| 49 | 21 21 21 37 21 33 29 8 60 25 15 0 25 30 70 30 0 25 30 25 5 | 50 21 42 16 21 38 29 0 39 8 66 20 10 5 45 45 5 5 45 70 25 20 10 0 |
| 51 | 11 11 74 5 25 4 67 4 55 4 10 85 5 0 0 0 100 0 | 52 21 26 37 16 17 46 33 33 4 10 60 15 15 10 10 10 80 30 35 35 0 | 53 32 0 47 5 13 58 29 0 75 10 75 10 5 30 5 50 25 25 25 0 |
| 54 | 5 32 63 0 46 25 25 0 25 8 75 5 15 5 15 5 60 5 35 35 0 | 55 11 5 58 16 46 21 42 33 4 70 5 15 5 15 5 60 5 35 35 0 | 56 16 32 47 5 25 38 29 8 66 20 10 5 45 45 5 5 45 70 25 25 25 0 |
| 57 | 0 47 37 16 17 46 33 33 4 10 60 15 15 10 10 10 80 30 35 35 0 | 58 11 0 68 21 38 4 46 13 75 4 10 75 10 0 10 10 5 55 5 40 40 0 | 59 21 0 47 32 33 13 54 0 70 5 15 5 15 5 60 5 35 35 0 |
| 60 | 21 16 58 5 17 42 33 8 50 20 20 30 20 0 20 0 10 40 25 25 25 10 | 61 26 16 47 11 33 13 54 0 70 5 15 5 15 5 60 5 35 35 0 | 62 32 5 53 11 46 4 50 4 45 4 10 45 4 10 40 20 0 40 35 35 0 |
| 63 | 11 11 53 26 11 21 46 29 4 70 10 70 10 0 20 0 0 35 30 30 5 | 64 11 32 5 53 11 46 4 50 4 45 4 10 45 4 10 40 20 0 40 35 35 0 | 65 21 16 53 11 0 92 8 0 50 35 15 15 0 20 40 35 35 0 |
| No | Chemical Bonding | Solution | Reaction Rate | Chemical Equilibrium |
|----|------------------|----------|--------------|---------------------|
|    | %KC %NKC %MC %E | %KC %NKC %MC %E | %KC %NKC %MC %E | %KC %NKC %MC %E |
| 66 | 26 16 37 21 8 0 | 79 13 45 0 55 0 25 0 | 50 25 |
| 67 | 26 0 68 5 21 8 | 63 8 50 5 40 5 | 15 10 65 10 |
| 68 | 26 0 63 11 29 8 | 50 13 55 0 35 10 20 5 | 65 10 |
| 69 | 16 37 42 5 25 8 | 38 33 4 40 25 20 15 15 65 15 5 |
| 70 | 21 16 42 21 17 25 | 54 4 55 5 35 5 | 30 25 40 5 |
| 71 | 21 5 53 21 17 38 | 42 4 65 15 20 0 | 30 45 20 5 |
| 72 | 21 11 53 16 8 46 | 46 46 0 65 15 20 0 | 30 50 10 10 |
| 73 | 11 21 58 11 13 50 | 38 0 40 10 50 0 | 15 60 20 5 |
| 74 | 0 58 37 5 17 46 | 33 4 40 25 30 5 10 45 45 0 |
| 75 | 5 47 47 0 33 21 | 42 4 30 50 20 0 | 15 70 15 0 |
| 76 | 16 0 68 16 29 0 | 71 0 65 0 25 10 | 15 0 65 20 |
| 77 | 5 37 47 11 29 38 | 33 0 60 10 25 5 | 45 40 10 5 |
| 78 | 11 0 74 16 29 38 | 29 4 35 10 35 20 | 20 40 30 10 |
| 79 | 16 16 42 26 29 13 | 54 4 50 5 40 5 | 30 25 35 10 |
| 80 | 5 47 37 11 17 58 | 25 0 60 30 0 10 | 10 60 20 10 |
| 81 | 11 63 21 5 25 50 | 21 4 70 5 20 5 | 15 55 25 5 |
| 82 | 11 21 53 16 21 | 46 25 8 35 20 30 15 25 40 30 5 |
| 83 | 0 95 5 0 13 83 | 0 4 0 100 0 0 | 0 90 10 0 |
| 84 | 0 100 0 0 8 92 | 0 0 0 100 0 0 | 0 100 0 0 |
| 85 | 0 95 0 5 13 71 | 13 4 0 100 0 0 | 5 95 0 0 |
| 86 | 21 0 58 21 17 0 | 79 4 50 0 45 5 | 35 0 60 5 |
| 87 | 5 21 68 5 29 29 | 33 8 20 15 65 0 | 10 45 40 5 |
| No | Chemical Bonding | Solution | Reaction Rate | Chemical Equilibrium |
|----|------------------|----------|---------------|----------------------|
|    | %KC | %NKC | %MC | %E | %KC | %NKC | %MC | %E | %KC | %NKC | %MC | %E |
| 88 | 16  | 21   | 42   | 21 | 0   | 50   | 29  | 35 | 5   | 40   | 20  | 10  | 15   | 65  | 10  |