A review of research trends on meta-cognitive in science education within the past decade

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Abstract. Metacognition and its implications for learning and instruction have become a central issue in educational research. The objective of the current review is mapping the field of meta-cognitive research trends in science education within the past decade. Furthermore, this study build the state of the art on meta-cognitive and describe the possibility research in future. This study as a baseline for further research which focus on metacognitive integrated with other skills. The survey was implemented as method for this research. The major purpose of surveys is to describe the characteristics of a population. The subject for this study is 30 articles which is focusing on meta-cognitive in science education and have highest citation within the past decade (year 2009-2019). The articles come out from databases ‘Google scholar’ and from reputable journals. Form of coding scheme is main instrument for this study. The finding describes that Research trends on meta-cognitive in science education dominant conducted in higher education for pre-service teachers. Furthermore, for metacognitive aspects generally focus on aspect Metacognitive Skills (MS) sub aspect regulating/controlling and Metacognitive Knowledge (MK) about strategies for science concepts in domain-general. Meanwhile, based on role, research on meta-cognitive focus as the input. The implication of research trends on meta-cognitive provide opportunities for conducting research in lower education for discipline-specific science. The further research also can assess on Metacognitive Experiences (ME) and Metacognitive Skills for sub aspect monitoring, evaluating and planning.

1. Introduction
The recent studies focus on how to apply the metacognitive in classrooms settings. The metacognitive instruction use to enhance the students’ knowledge and conceptual understanding, also for students’ skills namely reading skills, problem-solving skills or higher-order thinking skills [1]. There are three domains of metacognition, such as Metacognitive Knowledge (MK), Metacognitive Skills (MS) and Metacognitive Experiences (ME). Metacognitive monitoring and self-regulation as the aspects of Metacognitive Skills (MS) [2].

The facts show that metacognition can improve learning and instruction significantly, especially for science education. To analyze how the metacognition can integrate and interrelate with the varied, and often domain-specific, activities related to science learning as the main consideration for conducting research. The objective of the current review is mapping the field of meta-cognitive research trends in science education. Furthermore, this study builds the state of the art on meta-cognitive and describe the possibility research in future.
2. Methods
The survey was implemented as method for this research. The major purpose of surveys is to describe the characteristics of a population [3]. Furthermore, function of survey research is describing the trends [4]. Despite the many applications of surveys today, there are still only two basic types of research surveys. Due to the aim to study changes within some general population over a period of time, trend studies has been used. Population in this study is article on meta-affective and meta-cognitive in science education within the past decade. Trend studies are longitudinal survey designs that involve identifying a population and examining changes within that population over time. A survey has several characteristics and several claimed attractions; typically it is used to scan a wide field of issues, populations, programmes etc. in order to measure or describe any generalized features [5].

The subject for this study is 30 articles which is focusing on meta-cognitive in science education and have highest citation within the past decade (2009-2019). The articles come out from databases ‘Google scholar’ and from reputable journals. The first criterion was that the study title, journal title or abstract had to include an explicit reference to meta-cognitive or to any metacognitive component. The second criterion was that the study title, journal title or abstract had to include an explicit reference to science education or science education settings. Coding scheme as the research instrument which consist of list of aspect to analyse the component of articles. Furthermore, coding collection changed into frequencies and percentage as show in data.

3. Result and Discussion

3.1. Percentages of the role of meta-cognitive
The first result describes about role of meta-cognitive as shown in Figure 1.

![Figure 1. Percentages of the role of meta-cognitive](image)

As the input, strategies meta-cognitive or metacognition is helping student on focusing in achievement especially conceptual knowledge about science. These studies such as on students' science achievement for 7th-grade [6], content knowledge for 8th-grade students, physics learning for secondary school students [7]. Furthermore, metacognition is the significant predictors of science achievement for 7th-grade students [8], there is a very strong relation between the metacognitive and cognitive strategies [9].

3.2. Percentages of scientific disciplines studied
The second result describes about percentages of scientific disciplines studied by using study contexts domain-general, discipline-specific, and concept-specific as shown in Figure 2.
3.3. Frequencies and percentages of aspect which relation to meta-cognitive in science education

The third result describes about aspect which relation to meta-cognitive in science education as shown in Table 1.

| Aspect                              | Sub Aspect          | \( f \) | %  |
|-------------------------------------|---------------------|---------|----|
| Conceptual knowledge                | Content knowledge   | 2       | 6.7|
|                                     | Science concepts    | 8       | 26.7|
|                                     | Conceptual understanding | 0 | 0  |
|                                     | Conceptual change    | 0       | 0  |
|                                     | Knowledge construction | 0 | 0  |
|                                     | Misconceptions       | 0       | 0  |
|                                     | Models               | 0       | 0  |
| Higher-order thinking and inquiry learning | General thinking skills | 0 | 0  |
|                                     | Problem-solving      | 4       | 13.3|
|                                     | Inquiry learning     | 5       | 16.7|
|                                     | Specific thinking skills | 0 | 0  |
|                                     | Laboratory           | 1       | 3.3|
|                                     | Experiments          | 0       | 0  |
| Personal epistemology and self-regulated learning | Personal epistemology | 0 | 0  |
|                                     | Prior knowledge      | 0       | 0  |
|                                     | Self-regulated learning | 5 | 16.7|
|                                     | Motivation           | 0       | 0  |
|                                     | Regulation           | 0       | 0  |
|                                     | Self-esteem or efficacy | 0 | 0  |
| Reading and literacy                | Science texts        | 3       | 10 |
|                                     | Reading              | 0       | 0  |
|                                     | Scientific literacy  | 0       | 0  |
|                                     | Explanation          | 0       | 0  |
| Learner-related dimensions          | Reflection           | 0       | 0  |
|                                     | Academic achievements | 0 | 0  |
|                                     | Learning strategies  | 1       | 3.3|
|                                     | Learning experiences | 0       | 0  |
|                                     | Attitudes            | 0       | 0  |
|                                     | Nature of Science (NOS) | 1 | 3.3|
|                                     | Self-assessment      | 0       | 0  |
3.4. Frequencies and percentages of meta-cognitive aspects studied
The fourth result describes about frequencies and percentages of metacognitive aspects studied by using metacognitive aspects studied namely Metacognitive Skills (MS), Metacognitive Knowledge (MK), and Metacognitive Experiences (ME) as shown in Table 2.

Table 2. Frequencies and percentages of meta-cognitive aspects studied

| Meta-cognitive aspects studied | f | %  |
|-------------------------------|---|----|
| Meta-cognitive Skills (MS)    |   |    |
| Monitoring                    | 0 | 0  |
| Evaluating                    | 0 | 0  |
| Planning                      | 0 | 0  |
| Regulating/controlling        | 11| 36.7|
| Meta-cognitive Knowledge (MK) |   |    |
| About persons                 | 1 | 3.3|
| About strategies              | 17| 56.7|
| About tasks                   | 1 | 3.3|
| Meta-cognitive Experiences (ME)| 0 | 0  |

3.5. Number of studies by age group
The fifth result describes about number of studies by age group namely preschool, 1-3 grades, 4-6 grades, 7-9 grades, 10-12 grades, and higher education as shown in Figure 3.

Figure 3. Number of studies by age group

Nature of Science (NOS) as cognitive-epistemic and social-institutional has relation with metacognition. This aspect consists of set categories, namely aims and values, scientific methods, scientific practices, scientific knowledge and social-institutional aspects of science [10]. Teacher argument that reflective thinking as the basic of metacognition, since this metacognition focus on controlling and understanding of cognitive processes. Although Figure 3 shows that preschool and 1-3 grades are still lack for field of metacognitive research, most teachers believed that metacognition was appropriate for elementary students because the students had the cognitive capacity to think metacognitively [11].

4. Conclusion
Research trends on meta-cognitive in science education dominant conducted in higher education for pre-service teachers. Furthermore, for metacognitive aspects generally focus on aspect Metacognitive Skills (MS) sub aspect regulating/controlling and Metacognitive Knowledge (MK) about strategies for science concepts in domain-general. Meanwhile, based on role, research on meta-cognitive focus as the input.
5. References
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