# Types of Reasoning in Framing Based Plant Anatomy and It Relation to Spatial Thinking



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# Types of Reasoning in Framing Based Plant Anatomy and It Relation to Spatial Thinking

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**Abstract.** A study about the spatial framing in plant anatomy course was conducted to investigate the role of framing in improving student reasoning in understanding the structure and function of plant and its relation to spatial thinking. A number of biology students (n=35) at State University in South Sumatra, Indonesia was involved as participants in this study. Data was collected using reasoning test based on Marzano framework and spatial thinking instrument test that had been developed and based on expert judgment. Data obtained was processed by calculating the average and percentage (%) on each indicator. Research findings show that there was improvement in reasoning and spatial thinking of students after having experience through framing based learning with an average N-gain 51.9 and 46.6 (moderate category). Learning of framing based plant anatomy course improved the students reasoning at each indicator. Students reasoning before and after learning based framing instruction are: (1) comparing (41.1 and 87.4); (2) classifying (14.7 and 77.1); (3) inducing (28.6 and 64.6); (4) deducing (15.7 and 55.7); (5) analyzing error (21.9 and 40.0); (6) constructing support (33.3 and 54.3); (7) abstracting (31.4 and 34.3); and (8) analyzing perspective (38.3 and 47.1). Analysis of the relationship between reasoning related concepts of plant anatomy and spatial thinking showed r=0.454 (p=0.00*>0.01) (significant correlation). Further it was found that students' spatial thinking including generating a representation (i); maintaining a representations in working memory (ii); scanning the representation (iii); and transforming of representation (iv) are factors that improved student reasoning.

## 1. Introduction

Plant anatomy is one of the compulsory course for students of Biology Education. Demands of plant anatomy curriculum required students to understand the structure and function of cells, tissues or organs of plants which are three-dimensional (3D) structures. Plant anatomy generally includes a variety of topics: the anatomical structure of the cell, the ground tissue (parenchyma, collenchyma and sclerenchyma), dermal, vascular and secretory tissue, and the organs of plants such as roots, stems, leaves, flowers, fruits and seeds [1]. In addition, students should also be guided to understand the structure of plant anatomy in two-dimensional (2D) and three-dimensional (3D). For this purpose, it is indispensable spatial thinking ability (spatial thinking) for each student [2]. Spatial thinking is associated with problem solving through the coordinated use of space, problem representation and reasoning process3. Spatial thinking allows one to externalize relationship by creating a spatial

representation in a variety of media, forms, 2D graphs, tree diagrams or relationships, 3D scale models and other forms of structure3. Spatial thinking can be developed based on: (1) the concept of space; (2) the representation; and (3) the process of reasoning [3],[4].

The concept of space is generally relate to the conceptual framework and data analysis can be integrated, relevant and whole structure. Thinking about the space in various disciplines can be defined in various forms. In this study, the concept of space associated with making a proper incision in location of the tissues to be observed, using a right microscope scale, positioning the object properly with the focus of observation, identifying 3D-plant tissue, drawing or visualizing 2D and 3D tissues (representation). It is important to recognize the position of a tissue among other tissues to recognize the color, shape, size or other attributes, as well as to construct 2D to 3D structure or vice versa. Representation is the ability to describe or stimulate some ideas, concepts or objects [3] and a tool to visualization that potential and understanding were exploited to improve the quality of science education [5]. The spatial representation are important in all branches of biology, where 3D representation are crucial for understanding the phenomena [6]. Thinking spatially uses representation to help remember, understand, reason and communicate about the properties of and relations between objects presented. The spatial thinking process begins by distinguishing and coding of spatial features [3]. Reasoning process includes manipulating process, interpreting and explaining structured information. The powerful features of spatial thinking are to change, manipulate, operate on representation. Some of spatial transformation are: perspectives changing, orientation, the shape change, resize, and reconfiguration [3],[5],[7].

The previous research showed that visuospatial based learning of plant anatomy can improved students reasoning ability [8]. There is a correlation between spatial visualization, logical thinking and concepts of objects with different scales [9]. Moreover, involving students in building models of the 3D structure of the cell will improve the students' understanding on the structure and function of cells [10]. The studies showed that spatial visualization was required more in receiving spatial information. Thus the space visualization involves various spatial ability and the ability for mental rotation, manipulating and rotation as well as the construction of the stimulus 2D into 3D. Meanwhile the representation in this study is the ability of students to make representations, managing representations in working memory, scanning the representation and the ability to transform representation. This is done by using the concepts of plant anatomy. However, some research has not revealed specifically how to improve spatial thinking of students in plant anatomy concepts. How reframe of spatial thinking student that has roles in improving the student reasoning related to the plant anatomy concept.

Research on framing in learning has been done by several researchers. However, the framing in education and the learning process is still very rarely conducted [11]. Framing is an ongoing process that is dynamic, where people continue to frame how to understand "what is happening", in a small adjustment of the scheme [12]. Frame is individual's sense of "what is it that's going on here?" [13]. Framing, was more often used in journalistic discourse, that is related to how the media interpretation and frame cases or events reported. But in education, it was described that the framing as cognitive strategies to sequence and synthesize an information. Framing strategy is a visual arrangement that enables a substantial amount of information to be put in a form of grid, framework, spatial or matrix [14],[15]. Framing involves making connections of main ideas and the relationship between them, it might aid students' organization and comprehension of structural knowledge, and remembering as well [15]. This showed that the framing creates connections of main ideas and relation between them, which may help to organizing and understanding the structure of knowledge and the students remember ability. Framing refers to the process of meta-communicative formation of social reality in the classroom. A learning context has been framed when someone uses meta-communicative signals that help to construct what someone do in it, so that create a "frame" in activities can be interpreted [11],[16].

Some research on framing shows that dynamics of framing on process of practice biology learning and social reality context on biology learning process influence the scientific arguing ability of students [12],[17], resolving the cognitive pressure18, transferring and creating the ability to explain

[16] for the prospective teacher [19]. From these studies, it can be seen that framing can be performed on the learning process in the classroom or in the biology laboratory activities. However, the studies of how framing the situation in the classroom and laboratory activities when students use reasoning and solve problems related to spatial concept of plant anatomy has never been done previously. Therefore problem statement in this research is how to improve the reasoning ability of students to the concept of framing based plant anatomy? This paper focuses on investigating the role of framing to improve spatial thinking in learning plant anatomy. This paper describes how the learning of plant anatomy in the class and the laboratory occur are framed to promote spatial thinking. It was predicted that spatial thinking would be promoted by plant anatomy learning based framing. Spatial thinking will improve student reasoning related to the concept of plant anatomy. Focus of this paper discussion is on how to investigate an overview the role of framing in improving student reasoning in understanding the structure and function of plant anatomy and it relation with spatial thinking.

## 2. Methods

### *2.1. Participants*

This descriptive research was conducted at the Biology Education Study Program at a State University in South Sumatra, Indonesia. The activity of this study involved 35 students (33 females and 3 males). Participants of this research were the third semester students who take plant anatomy course. Instruction in plant anatomy course was generally consistent with a framing. In most lesson, student receiving information from the lecturers, identification of important concept, verbal representation, scanning 2D and 3D structure, constructing 2D to 3D picture or vice versa, constructing 3D model of plant tissues and refining concept.

### *2.2. Instrument test and procedure*

Two instruments used in this research are spatial thinking instrument and reasoning of plant anatomy concepts instrument. These instruments were developed thoroughly, which were then validated by experts and through field testing. Spatial thinking instrument was specifically designed for the study in the form of multiple choice test items. To give a comprehensive measure spatial thinking, the instrument employed four indicators, such as; (1) generate a representation; (2) manage and maintain a representation in working memory; (3) scan a maintained representation in working memory; (4) transform a representation with rotation or view the object from different perspective [3],[20]. Meanwhile, the reasoning of plant anatomy concepts instrument was developed based on Marzano's framework, that are: comparing ability, classify, inducing, deducing, analyzing an error, constructing a support, abstracting, and analyzing a perspective [21].

Participants were tested with spatial thinking and reasoning of plant anatomy concepts instrument at the beginning and at the end of the framing based plant anatomy learning. Framing based plant anatomy learning used to improve spatial thinking of Biology students on plant anatomy concept. Dynamics of framing was adopted and modified from framing term [3],[13],[16],[18]. Dynamics of framing was specifically designed: concepts questions, spatial related concepts question, direction sentences [22] and also examples of 2D and 3D plant anatomy picture that had been constructed well (worked examples). Dynamics of framing directed the students to think spatially on plant anatomy concepts. The questions used consisted of non-spatial questions about anatomy concept and spatial relating concepts questions. Directing sentences used to guide spatial thinking process of students gradually. Worked examples used to reframe spatial thinking process of students while constructing 2D to 3D or vice versa, transforming representation and imagine the tissues structure from different perspective.

### *2.3. Data analysis*

Test was administered at the beginning and the end of ground tissues concept learning. The Data was analyzed both quantitatively and qualitatively. Quantitative data obtained with calculated the average

or percentage on every indicator of spatial thinking and reasoning related concepts. Criteria of spatial thinking and the reasoning ability in plant anatomy was classified by reference and modified from [23] that is: ≤ 34 (very low); 35-50 (low); 51-65 (medium); 66-80 (high); ≥ 81 (very high). The improvement in reasoning and spatial thinking of student after having experience framing based learning was done with an average N-Gain [24]. Correlation between the scores on spatial thinking and reasoning ability was calculated with pearson correlation coefficients (SPSS 22). Qualitative data was analyzed from observation on framing based plant anatomy learning process.

## 3. Result and discussions

Research findings show that there was improvement in reasoning and spatial thinking of students after having experience framing based learning with an average N-Gain 51.9 and 46.6 (moderate category). Learning of framing based plant anatomy course improved the students reasoning at each indicator. Students reasoning before and after learning with framing based instruction are in Table 1.

**Table 1.** Percentage of the reasoning ability of basic tissues.

| Indicator of Concepts Reasoning | Pretest | Criteria | Posttest | Criteria |
|---|---|---|---|---|
| Comparing | 41.1 | Low | 87.4 | Very High |
| Classifying | 14.7 | Very Low | 77.4 | High |
| Inducing | 28.6 | Very Low | 64.6 | High |
| Deducing | 15.7 | Very Low | 55.7 | High |
| Analyzing an error | 21.9 | Very Low | 40.0 | Low |
| Constructing Support | 33.3 | Very Low | 54.3 | Medium |
| Abstraction | 31.4 | Very Low | 34.28 | Low |
| Analyzing a Perspective | 38.3 | Low | 47.14 | Low |

*Note: Very high (75-100); High (67-74); Medium (51-60); Low (35-50); Very Low (≤34)*

The data on Table 1 shows that the comparison of students reasoning ability before and after framing based learning instruction indicate most of each indicator moves from very low to high (or even very high), except on the last three indicators (medium for constructing support, low for abstraction, and still low for analyzing a perspective).

These research findings are similar and supported by other previous research findings, such as that framing on process of practical biology learning and social reality context on biology learning process influence the scientific arguing ability of student [12],[17], resolving the cognitive pressure and improve working memory capacity18, transferring and create the ability to explain [16], for the prospective teacher [19].

The higher score of the reasoning ability was comparing indicator (87.4), and the lowest score was abstraction indicator (34.4). The low score at posttest were analyzing an error, abstraction and analyzing a perspective. This study showed that the framing was not fully play role in improving reasoning, especially for that three things. According the observation results in the classroom, showed that student was difficulty in constructing the structure of 2D to 3D or otherwise and transforming representation. These results are related to the managing and transformation representation of spatial thinking indicator on posttest (Table 2). This study investigated the need to promote reasoning ability and spatial thinking. Research study on framing indicated that dynamics of framing on process of learning can resolving the cognitive pressure [18] and improve spatial working memory. In order to help undergraduate students to develop spatial thinking and reasoning ability, it will be designed and repaired dynamic framing. Repaired framing designed will be given at construction and transformation representation steps.

**Table 2.** Percentage of spatial thinking on basic tissues concept.

| Spatial Thinking Indicator | Pretest | Posttest | Criteria |
|---|---|---|---|
| Result in a representation | 32.3 | 85.7 | Very High |
| Managing a representation | 20.0 | 47.4 | Low |
| Scaning a representation | 21.1 | 76.6 | Very High |
| Transforming a representation | 13.3 | 32.9 | Low |

*Note: Very high (75-100); High (67-74); Medium (51-60); Low (35-50); Very Low (≤34)*

Based on Table 2, the highest spatial thinking was create a representation ability (85.7) and the lowest was the managing (47.4) and transforming representation ability (32.9). It is mean that on function of the framing test had not trained the construction and transforming representation ability fully. Result of the research was showed that students can't constructing a representation to the full. In plant anatomy, students must managing a representation ability to constructing two dimensional picture into three dimensional picture or otherwise. This is accordance to [3], Managing and maintaining a representation in working memory is students ability in manage the available representation and use it to solve the problem.

In plant anatomy, transforming a representation was created by plant anatomy material needs, rotating, viewing a tissue from different perspectives and from different positions. Students can know the shape, characteristic, and position of a tissue among other tissues from scanning and transforming a representation. Scanning a kept representation on working memory or fast thinking in representation, means to focus the attention on several parts of available representation [3]. In this research, scanning a representation was done by knowing parts of position and characteristic of plant tissues according to available representation. This study showed that most of student was difficulty to create transforming representations. This result have correlation with the low student reasoning at abstraction and analyzing a perspective (Table 1). These results are also supported by some results on previous studies on transformation representation that showed transformation representation related to spatial ability function that is a form of individual mental activity to create spatial image and manipulate a representation (changed with folding, rotating and compressing), to solve any practical problems and theoretical problems [25],[26],[27],[28],[29].

Analysis of the relationship between reasoning related concepts of plant anatomy and spatial thinking showed $r = 0.454$ ($p = 0.00^{*}>0.01$) (significant correlation). Student with low spatial thinking have low reasoning related concepts, and student with high spatial thinking have high reasoning related concepts. Improving in spatial thinking will improve the reasoning related concepts. This study is appropriate with the previous study that student with low spatial abilities make more error [25], whereas student with high spatial abilities perform better in concept mastery [30],[31].

## 4. Conclusion

Based on this study show that there was improvement in reasoning and spatial thinking of students after having experience through framing based learning with an average N-Gain 51.9 and 46.6 (moderate category). Learning of framing based plant anatomy course improved the students reasoning at each indicator. Students reasoning before and after learning based framing instruction are (i) comparing 41.1 and 87.4; (ii) classifying 14.7 and 77.1; (iii) inducing 28.6 and 64.6; (iv) deducing 15.7 and 55.7; (v) analyzing error 21.9 and 40.0; (vi) constructing support 33.3 and 54.3; (vii) abstracting 31.4 and 34.3 and (viii) analyzing perspective 38.3 and 47.1. Analysis of the relationship between reasoning related concepts of plant anatomy and spatial thinking showed $r = 0.454$ ($p = 0.00^{*}>0.01$) (significant correlation). Student spatial thinking including generating a representation (i); maintaining a representations in working memory (ii); scanning the representation (iii); and transforming of representation (iv) are factors that improved student reasoning.

In the study as indicated, most of students have low in managing and transformation representation that influence low reasoning in analyzing an error, abstraction and analyzing in perspective. These

activities are necessary to facilitate the framing in constructing and transforming representation. Regarding the result, needs to repaired strategy of framing to improve spatial thinking process, specifically in constructing 2D into 3D or vice versa, and transforming representation with creating view of a tissue from different perspective, rotation, and scanning representation. Analysis of the relationship between reasoning related concepts of plant anatomy and spatial thinking showed significant correlation. Student with low spatial thinking have low reasoning related concepts, and student with high spatial thinking have high reasoning related concepts. This study as indicated, spatial thinking including generating a representation (i); maintaining a representations in working memory (ii); scanning the representation (iii); and transforming of representation (iv) are factors that improved student reasoning.

## 5. References

[1] Tasmania and Ermayanti 2013 *Syllabus of Plant Anatomy* (Palembang: FKIP Sriwijaya University) pp 1-30
[2] Ermayanti, Rustaman N Y and Rahmat A 2015 *Proc. National Conference Biology Education-2015 (Palembang)*, ed Susanti *et al* (Palembang: FKIP Universitas Sriwijaya) pp 248-55
[3] National Research Council 2006 *Learning to think Spatially* (Washington DC: The National Academies Press) pp 10-25
[4] Diezmann C M and Lowrie T 2012 *International Journal of Science and Mathematics Education* **10** 1469-90
[5] Gilbert J K 2005 *Visualization in Science Education* (Netherlands: Springer) pp 1-5
[6] Bolotin M Mand Nashon S M 2012 *Protoplasm* **249** S25-S30
[7] Mathewson J H 1999 *Sci. Education* **83** 33-54
[8] Suprapto P K 2012 *Pengembangan Program Perkuliahan Anatomi Tumbuhan Berbasis Visuospasial melalui Representasi Mikroskopis Sistem Jaringan Tumbuhan untuk Meningkatkan Penalaran dan Penguasaan Konsep Calon Guru Biologi* (Bandung: Disertation, Universitas Pendidikan Indonesia)
[9] Jones M G, Gardner G, Taylor A R, Wiebe E and Forrester J 2010 *Research Science Education* **41** 357-68
[10] Lazarowitz R and Naim R 2013 *Science Education Technology* **22**
[11] Eagle R A 2006 *Journal of the Learning Sciences* **15** 451-98
[12] Berland L K and Hammer D 2012 *Research in Science Teaching* **49** 68-94
[13] Goffman E 1974 *Frame Analysis: An Essay on The Organization of Experience* (Boston: Northeastern University Press)
[14] Van P, Chao J, Reigeluth C M 1986 *Review of Education Reaserch* **56** 437-71
[15] Awofala A O A, Ariqbabu A A and Awofala A A 2013 *Acta Ditactia Napocensia* **6** 1-22
[16] Eagle R A, Nguyen P D and Mendelson A 2011 *Instr. Science* **39** 603-28
[17] Boerwinkel D J, Swierstra T and Waarlo A J 2014 *Science & Education* **23** 485-507
[18] Autin F and Croizet J C 2012 *Experimental Psychology* **141** 610-8
[19] Subramaniam K and Harrell P E 2013 *Sci. Teacher Education* **24** 1177-99
[20] Koslyn S M *Journal of Experimental Psychology: Human Perception and Performance* **4** 47-60
[21] Marzano R J, Pickering D and Mctighe J 1993 *Assessing Students Outcomes: Performance Assessment using The Dimensions of Learning Model* (USA: Association for Supervision and Curriculum Development) pp 67-83
[22] Injeong I 2007 *Aspect of Spatial Thinking in Geography Textbook Questions* (Texas: Ph.D. thesis, Texas A&M University)
[23] Bao L *et al* 2009 *Education Forum* **232** 586-7
[24] Meltzer D E 2002 *American Journal of Physic* **70** 639-54
[25] Hegarty M and Waller D A 2005 *Individual Differences in Spatial Abilities* (New York; Cambridge University Press) pp 121-69
[26] Hegarty M and Waller D A 2004 *Intelligence* **32** 175-91

[27] Koshevnikov M, Motes M and Hergarty M 2007 *Cognitive Science* **31** 549-79
[28] Hegarty M and Kozhevnikov M 1999 *Eduation Psychology* **91** 684-9
[29] Miyake A, Friedman N P, Rettinger D A, Shah P and Hergarty M 2001 *Exp. Psychol. Gen*. **130** 9621-40
[30] Yang E M, Andre T and Greenbowe T J 2003 *Int. J. Sci. Education* **25** 329-50
[31] Hoffler T N 2010 *Education Psychology Rev*. **22** 245-69

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