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Assessing Visual Spatial Intelligence on Biology Content

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Abstract. One of the assessments in the learning processes is assessment of skills, the drawing is one of the competancy components standard of graduation in 2013 curriculum. However, teachers rarely do this assessment during the learning process instead microscopic practicum on abstract material including biology subjects. The research aim is to assess students' spatial visual intelligence on plant cell material and plant tissues, find out understanding concepts and student responses to apply spatial visual learning. The participants were 20 students SMA NW Pancor. Data collection used was students' worksheets, and questionnaires. The data analysis was qualitative descriptive. The findings, spatial visual intelligence was seen when the teacher asked students to draw 2D cells and plant tissues before began to the core material, but did not appropriate with its' original design. There are differences in the acquisition of scores on plant cell and tissue material, this proves that to help students' memory in making 2D images and understanding concepts, contextual media is needed such as by showing real objects and or it can also be done practicum. Therefore, the teacher can identify early about assessing the spatial visual competence, it was done by looking at the similarity of images made to the original, from the images made can be seen the students' concepts mastery of the material being taught.

Keywords: visual spatial, concepts mastery, plant cells, plant tissu

Introduction

The implementation of the 2013 curriculum in the schools requires the use of constructivist learning strategies in the learning process. Therefore, the teacher certainly designs learning that can train the way of students' thinking, especially high-level thinking and training of intelligence possessed by students (Lufri & Yogica, 2018). Mummah, et al., (2016) argues the current education system aims at designing learning and assessment creatively then effectively using an interdisciplinary approach. So that children have the same opportunity to hone their intelligences through the experiences and opportunities provided. Because through education, individual potential can be transformed into competencies that reflect the ability and skills of individuals in carrying out their duties or work (Apriana, et al., 2019). Green & Batool (2017), there are three domains assessed in each learning for all subjects namely the attitude domain, the skill domain and the cognitive domain. However, teachers tend to only assess the cognitive domain; the domain of skill is rarely assessed, especially learning for material that is abstract. Whereas in the standard competency of graduates has been determined for the domain of skill, the abstract element can be done by reading, writing, calculating, drawing, and composing using certain strategies. (Simplicio, 2019) states Educators must realize that using components of an effective strategy independently does not guarantee student success.

Each individual has a different intelligence, intelligence that has been owned needs to be developed in learning. Children have different abilities and intelligence developments and it can be developed through various daily activities, formally and informally (Pritchard, 2017). However, the development process is certainly influenced by internal factors (genes and families) and external factors (social environment) (Fatimah, et al., 2020). Therefore, the children have a level of intelligence and at an adequate level because each intelligence has a time of appearance and development (Dweck & Bempechat, 2017).

According to (Hayati, 2018), intelligence is the ability to have three components, namely the ability to solve problems, to produce new problems, and to create things. Gardner provides various ways to divide the abilities possessed by humans by grouping their abilities into eight comprehensive intelligences including Linguistics, logical mathematics, spatial, kinesthetic, music, interpersonal, intrapersonal, and naturalist (Shearer & Karanian, 2017). The eight intelligences are known as multiple intelligence or advanced intelligence. (Sternberg, 2018) defines multiple intelligence as the skills and talents a person has to solve problems in learning. By understanding the concept of multiple intelligences, at least the educator is wiser in seeing individual differences in class and making them feel more accepted in the school environment (Sullivan & Puntambekar, 2019). The ability to develop multiple intelligence of students can be trained in learning, of course, adapted to the appropriate material (Wongthongtham, et al., 2018). Gani, et al. (2017) in the learning process, the teacher tries the best way to teach all science content, but something is missed such as visualizing abstract scientific concepts to the students (Ryoo & Bedell, 2017). The statement was recognized by one of the biology subject teachers of High School at *NW Pancor* that the teacher was not yet familiar with the term multiple intelligence, but also did not really master learning strategies, especially in abstract biology material. This has become one of the causes of lack motivation, and lack of student focus in receiving subject matter so that it has an impact on student learning outcomes. (Andrews, et al., 2019) that the problem is often experienced by teachers that students does not focus on capturing facts, and biological concepts so that interest in learning is lost and the lack of experience in learning biology.

In biology subject of high school, some of materials are abstract to be taught, microscopic observations are needed to clarify the understanding of students material. Usually, if students conducted microscopic observations, the teacher asked students to draw the results of their observations. However, the drawings made by students were not appropriate with the preparations observed, whereas the teacher can identify students' spatial visual abilities. Visual spatial is one type of multiple intelligence, this type of intelligence is generally learned in certain fields as conducted by previous researchers namely (Şener & Çokçalışkan, 2018) examining spatial visual intelligence in dyslexic people who have deficits of attention to the difficulties in coding letter position. (Cho, 2017) an investigation of design studio performance in relation to creativity, spatial ability, and visual cognitive style. (Hronsky & Kreuzer, 2019) state that applying spatial prospectivity mapping to exploration targeting: fundamental practical issues and suggested solutions for the future. (Mammarella, et al., 2019.) reviewed a population's numerical ability that presents atypical visual spatial processes: individuals with blindness, hem neglect, children who have low visual spatial abilities, non-verbal learning disorders or Williams syndrome. (Thuneberg, et al., 2018) observed How creativity, autonomy and visual reasoning contribute to cognitive learning in a STEAM hands-on inquiry-based math module. (Özer & Göksun, 2020) investigated visual-spatial and verbal abilities differentially affect processing of gestural vs. spoken expressions. (Ben-Eliyahu, et al., 2018) investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. (Leblebđcđoğlu, 2012) an investigation of the relationship between working memory capacity and verbal and mathematical achievement. (Sudatha, et al., 2018) the effect of visualization type and student spatial abilities on learning achievement. Based on some of the previous research findings, the researcher wants to apply visual spatial in learning process, while the research questions asked are; 1) how to assess students' visual spatial abilities, 2) whether students can understand the concept using visual spatial, and 3) what are the students' responses to this spatial visual learning?

Methods

This research was pre-experiment with a pre-test and post-test design because there is no control group in the treatment, data collection was conducted twice were the meeting on 31 July 2019 and 14 August 2019. Each meeting was held a pretest to know prior knowledge visual spatial ability students and after that a posttest was held. The first meeting is about plant cells and the second meeting is about plant tissue. There were 20 respondents of High School. Data collection used was students' worksheets (see picture 1. Students' visual spatial assessment and concepts mastery were adopted from research conducted by (Fatmawati, 2019)**.** Data analysis techniques use the formula and the criteria from Hake (Savinainen & Scott, 2002) and the results obtained were qualitative descriptive. Here's the formula from Hake.

$$g = \frac{(s\ post - s\ pre)}{(s\ max - s\ pre)}$$

Ket: g = increase score

S_{post} = final test score
S_{pre} = initial test score
S_{max} = maximum score

Based on the results of the Gain score obtained then it was categorized into the criteria below:

No.	Score Gain	Category
1.	g <0.3	Low
2.	0.3 ≤ g ≤ 0.7	Medium
3.	g> 0.7	High

Results and Discussion

In the classroom, before the learning process conducted, students already bring a variety of knowledge gained from experience both from reading results, seeing what happens during socializing ,and interacting with their environment, as expressed by (van Aalderen-Smeets & van der Molen, 2018) someone can become smarter through experience. The experiences brought to class by students can be in the form of facts, beliefs, assumptions, perceptions, and skills. In learning known as initial knowledge and this initial knowledge was constructed during learning by the teacher.

Before starting the lesson, the teacher can identify the students' knowledge in order to find out their abilities or intelligence. In this process, the results of the identification can be used to determine the learning strategy to be used, and then adjusted to the material. The initial identification process of students' knowledge can also be conducted in biology subjects, because some of the materials were abstract, the teacher needed an analogy so that students were provoked into learning. However, in the learning process, these materials sometimes require microscopic observations so students can understand the results of microscopic observations obtained need to be poured into the form of images. The ability to draw is one of the intelligence that were in individuals and was part of the eight intelligences put forward by Gardner, namely spatial visual intelligence. To find out the spatial visual intelligence of students' biology material, the teacher can identify early by giving an analogy then directing students to make sketches or drawings, the goal is that students can pour their imagination into the form of images. Cabeen, et al. (2017) states that spatial in science includes drawing new discoveries that showed all the parts that work, assessments by assessing the images made. Then to teach spatial learning can be through seeing, drawing, watching, coloring, and making mind maps.

Based on these theories, researchers conducted visual spatial learning on plant material and plant tissue, assessments were conducted by looking at the similarity of images made to the original, and concepts mastery based on the images made. Spatial visualization involved mental information-based spatial information on objects and is assessed through intrinsic-dynamic skills (Zwartjes, et al., 2017) in addition, the students having intrinsic-dynamic skills, visual-spatial learning had special characteristics such as discovering new patterns resulting from his imagination but did not change the essence of the material being studied, as stated by (Kurniati, et al., 2018) that visual-spatial intelligence consists of 4 characteristics, namely imagination, conceptualization, problem solving and pattern determination.

The following describes the process of visual spatial learning and assessment. First meeting of cell matter; before learning began the teacher asked students about cells, and they knew but didn't know its form yet. So, the teacher asked the students to draw pictures about cells. To help students' memories, the teacher gave an analogy about the shape of the cell using egg, then students were asked to draw and generally students draw plant organs similar to the original such as trees, leaves, and stem, for example can be seen in figure 1. This analogy is needed to help recall students' memories so that they can solve a given problem. Collins, et al. {2017) argues that working memory is assumed to ensure the availability of information learned previously as integrated information to solve the problem. After discussing cell material both and making observations, students were asked return to draw cell shapes. However, students drew more observations that had been made (see figure 2).

The second meeting discussed the plant tissue; the teacher asked the students again to draw a form of plant tissue including roots, stems and leaves. To stimulate the imagination of students, this time the students were given the real object of the corn plant with the aim that students more easily make a picture of plant tissue (see figure 3, look for the results of student drawings). Observing real objects was one way to accommodate children's visual intelligence, so that children can actualize themselves and developed their abilities, and understand concepts easily Johnson (2019). This is one of the advantages for learning because it can train students' memory in remembering abstract objects. According to Hindal (2014) one of the advantages of applying visual spatial learning is that students have strong memory, see things holistically, and answer questions easily.

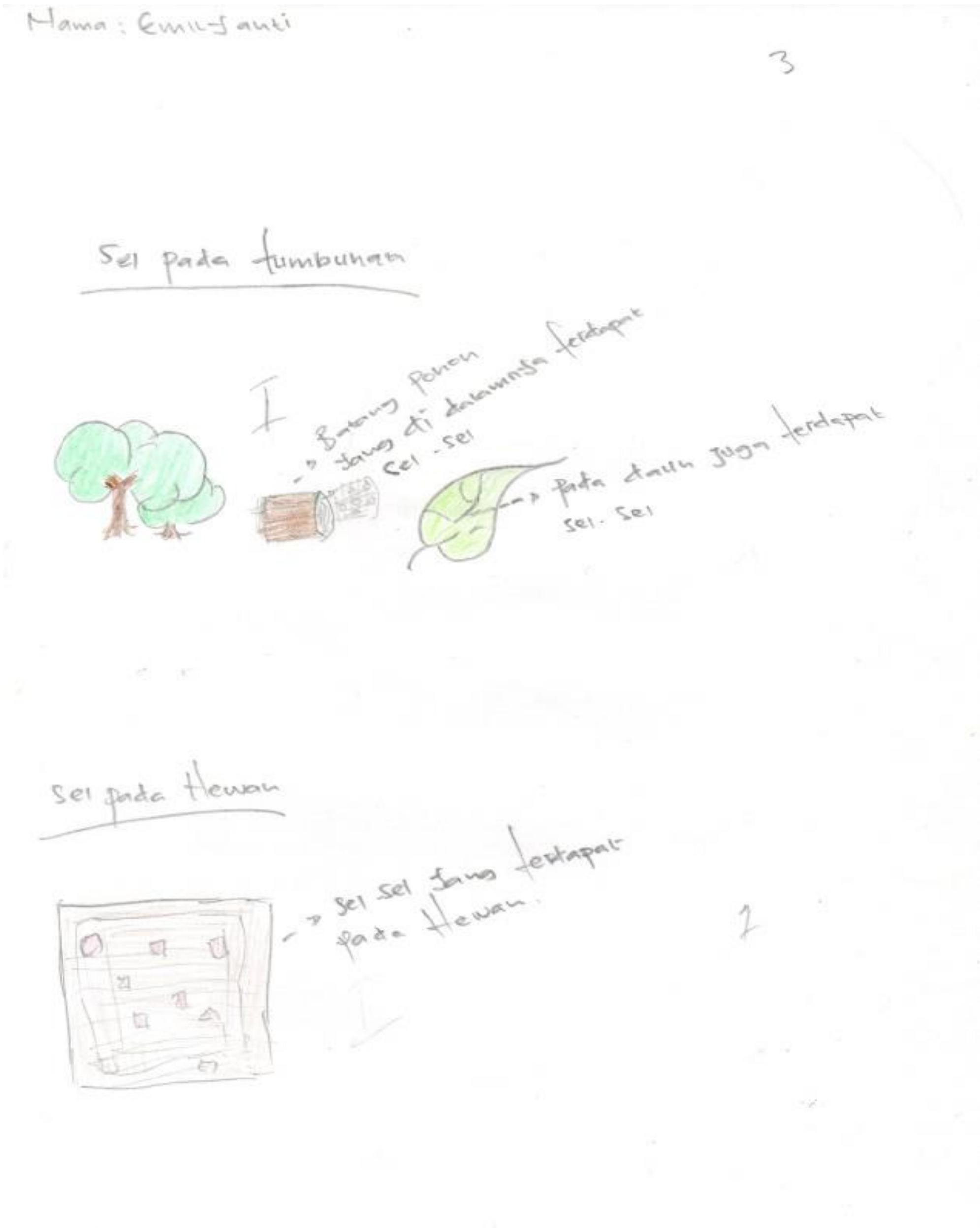


Figure 1. Cell Pigure made analogically by the students

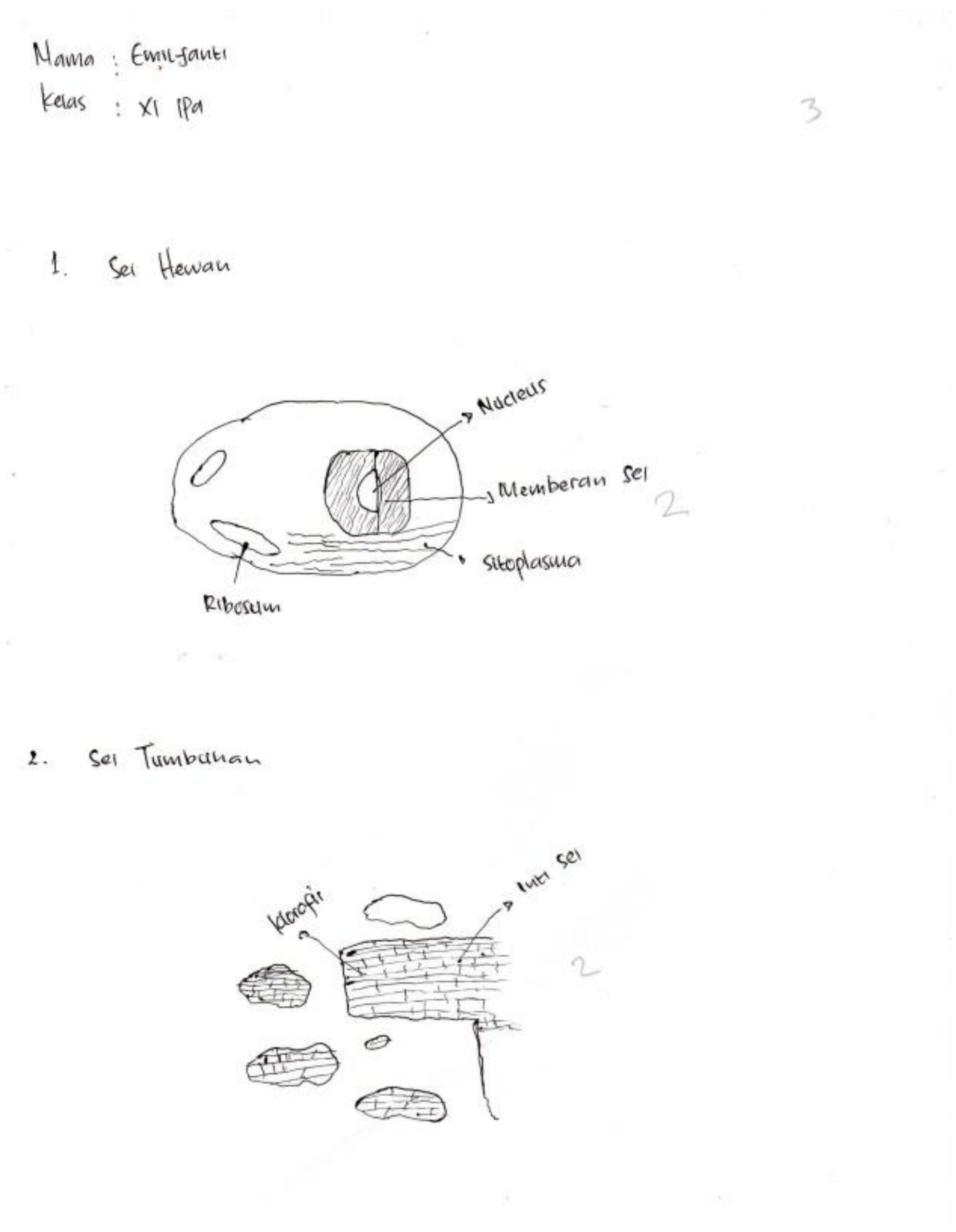


Figure 2. Cell Pigure made students after visual spatial learning

Visual spatial intelligence was one of intelligence in understanding phenomena. Biologically, according to (Collins, et al., 2017), the human visual system starts in the retina and then continues to the lateral geniculate core and then to the extra striate cortex. Whereas (Collins, et al., 2017) stated in terms of children's mental processes, that what happens during spatial thinking is that students analyze and draw conclusions from spatial relationships. However, modern theorists believe that spatial ability is influenced by natural and nurturing factors (Rubenstein, et al., 2018). With this spatial ability, it is expected that students' creativity in drawing will arise, as suggested by (Herrera, et al., 2019) that spatial ability has a unique role in the development of creativity. Next, on the students network material were asked return to draw a network shape and it turns out students draw more observations such as in cell material (see figure 4, look for the results of students' drawings). The results of microscopic observations on biology material needed to be represented so that the shape and appearance of the object of observation can be understood, so that other people who see also know. (Song, et al., 2018) argued that in the development of biology, spatial representation became an important dimension in the branch of biology, moreover by using 3D and 4D representations to support/facilitate understanding of phenomena. Likewise with (Reilly, et al., 2017) the relationship between spatial ability and biology, there are 2 ways namely spatial ability can help learning and achievement of biology, but the knowledge and skills of biological practicum can improve spatial ability.

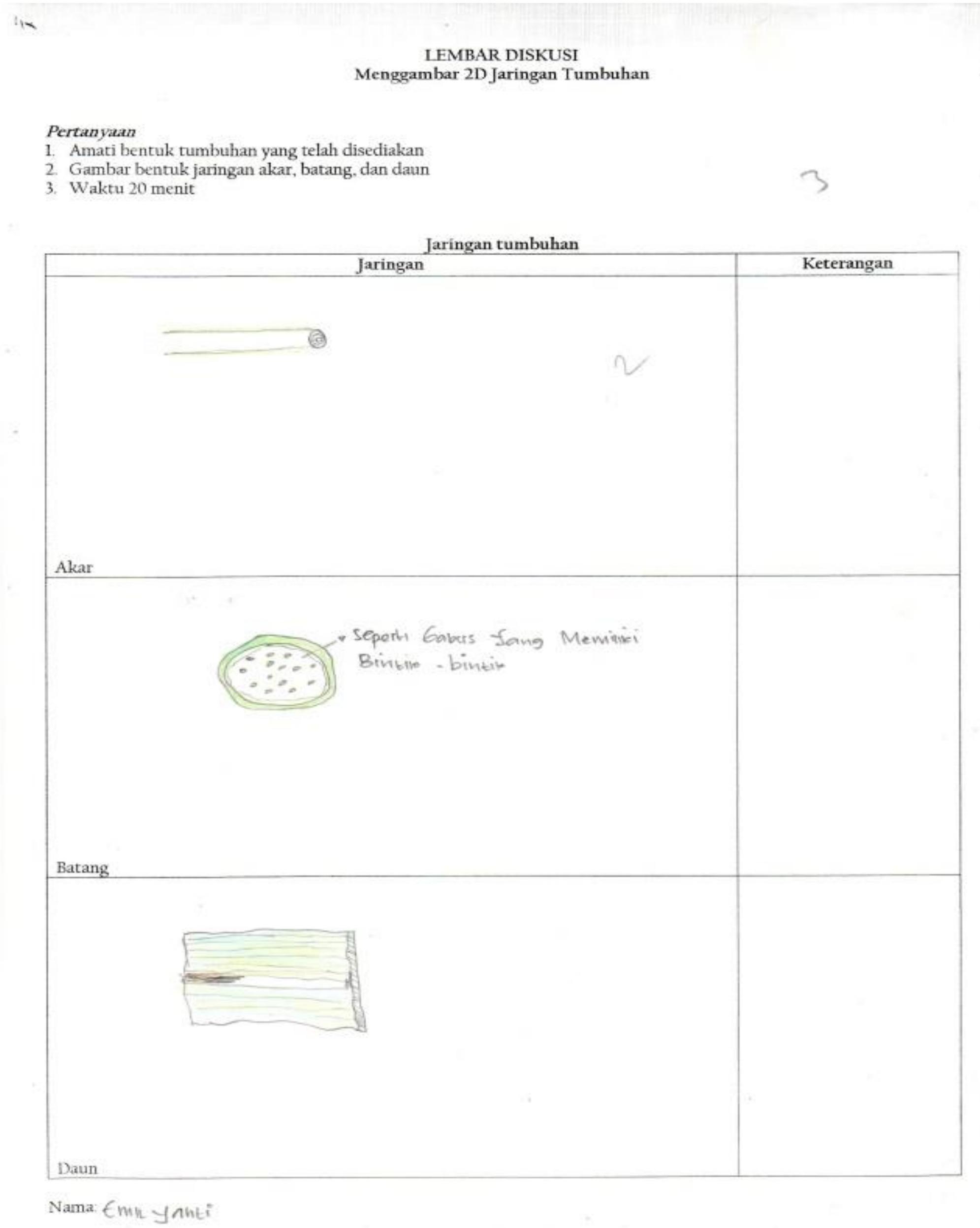
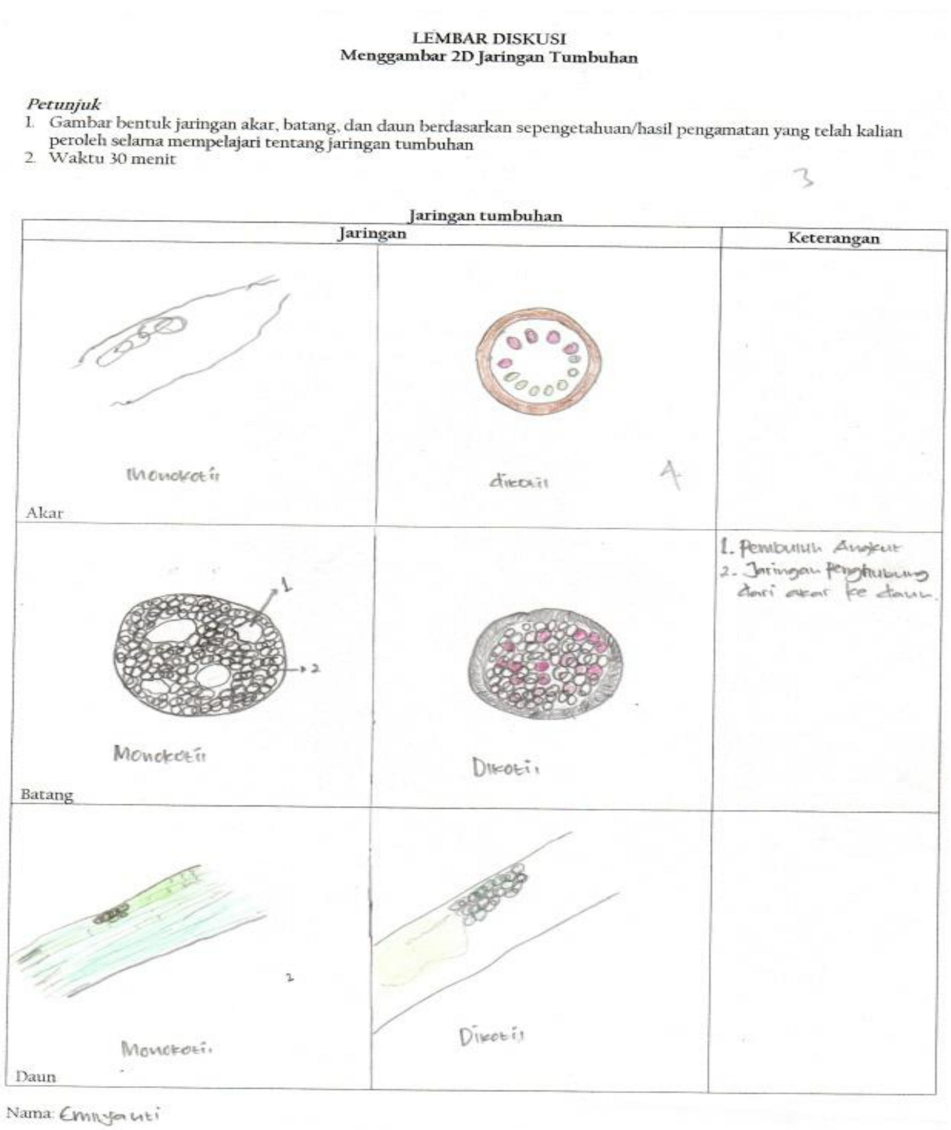


Figure 3. The Pigure of Plant Cell Made by the Students Observation Based


LEMBAR DISKUSI
Menggambar 2D Jaringan Tumbuhan

Petunjuk
1. Gambar bentuk jaringan akar, batang, dan daun berdasarkan sepengetahuan/hasil pengamatan yang telah kalian peroleh selama mempelajari tentang jaringan tumbuhan
2. Waktu 30 menit

Jaringan tumbuhan

Jaringan		Keterangan
Monokotil Akar	dikotil	
Monokotil Batang	Dikotil	1. Pembuluh Angkut 2. Jaringan penghubung dari akar ke daun
Monokotil Daun	Dikotil	

Nama:

Figure 4. The Pigure of Plant Cell Made by the Students after visual spatial learning

Spatial skills can be used to distinguish shapes and colors of abstract objects, expressed in the form of image patterns, and it was one form of the representation. Spatial learning provides an overview of the representation of the object imagined and the results can be different. (Bau, et al., 2017) explained the use of representations that the certain representations can explain the uniqueness of different representations. Based on the results of drawings made by students, it seems that students did need real objects to help their imagination draw so that the results obtained were as close to the original as possible. (Hawes, et al., 2017) his research and concluded that children have intrinsic-dynamic skills which are skills in spatial thinking by means of students being given a small set of models to change by rearranging, cutting, folding in making their findings. According to (Gani, et al., 2017), visual-spatial intelligence is a skill to capture visual space appropriately. By the existence of real objects, students' spatial ability develops during the learning process. Like Piaget & Inhelder's theory in (González, et al., 2017) Individual spatial abilities develop in 3 stages, namely: 1) children acquire two-dimensional abilities and learn the relationships between objects; 2) children learn to manage the training orientation of three-dimensional objects and rotational abilities; 3) individuals learn to connect space in the form of two dimensions and three dimensions by remembering, identifying and controlling concepts. A good educator is able to detect the intelligence of children by observing the behavior, tendencies, interests, ways and quality of children when reacting to a given stimulus. For the assessment of concepts mastery was done by assessing the images made by the aim at finding out the increase in concepts mastery of the material being taught (see figure 5) by this visual spatial learning. Students learned when they were able to gain between new concepts with knowledge or concepts they already knew. The differences in the way of the learning process and integrate new information can find the differences in memorizing, thinking, applying, and creating new knowledge. So that this gave students the profile of the abilities possessed, especially visual spatial abilities. Altiner & Dogan (2018) states that visual thinking profile plays an important role in the ability of spatial reasoning and student problem solving performance.

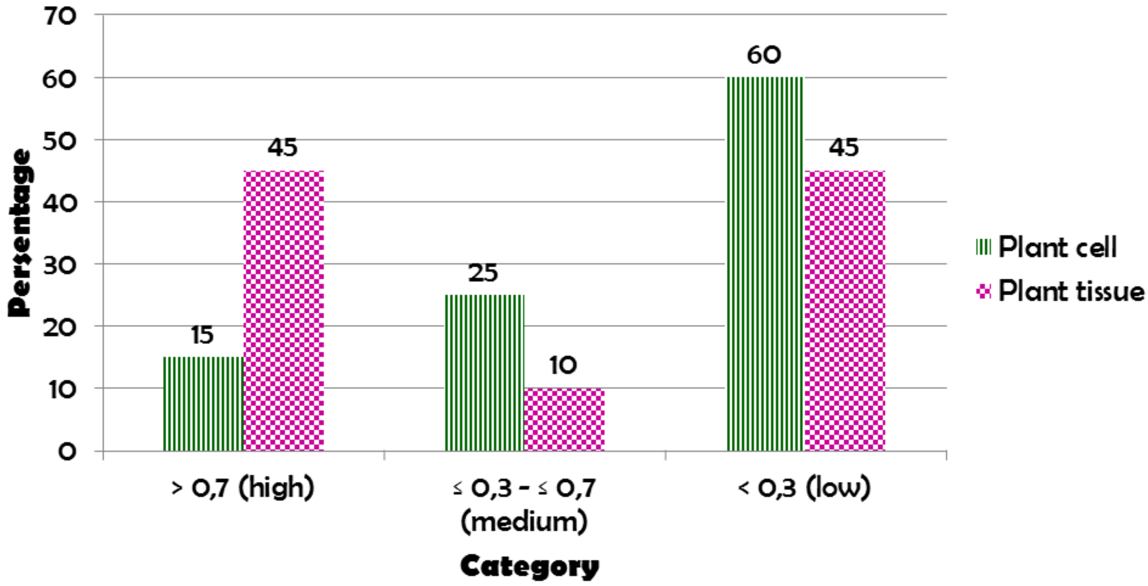


Figure 5*.* The increasing of concepts mastery using visual partial learning of biology*.*

Based on the results of figure five for the mastery concept, it can be seen that there are differences in the acquisition of scores on plant cell and tissue material, this proves that to help students' memory in making 2D images and understanding concepts, contextual media is needed such as by showing real objects and or it can also be done by doing practicum. The same finding was stated by (Gani, et al., 2017) several researchers related to spatial visual learning in biology learning spatial ability facilitates learning and achievement of biology from textual and visual content. Fiantika, et al. (2018) improving spatial ability can be achieved by changing one representation to another such as 2D representation into concrete 3D. (Winarti, et al., 2019) students had visual spatial intelligence from the beginning of learning but the intelligence needed to be sharpened, trained, and developed in the learning process because this intelligence involved the students' hands on and minds on. Suryawati & Osman (2017) states using appropriate techniques with the material so that students have the opportunity to interact so that optimal learning achievement was obtained.

Learning experience was experienced by students through a learning process that had been implemented, the experience gained naturally varies such as concentration of learning, obtaining new information from other friends, dare to argue, curiosity, comfort in learning, increased understanding of material, and high motivation. The students' experiences certainly cannot be separated from the learning strategies used by teachers in the classroom, one of them with this visual spatial learning. Learning experiences through spatial visuals got positive responses from students, data was taken by filling in a number of questions given to students after completion of learning (see figure 6).

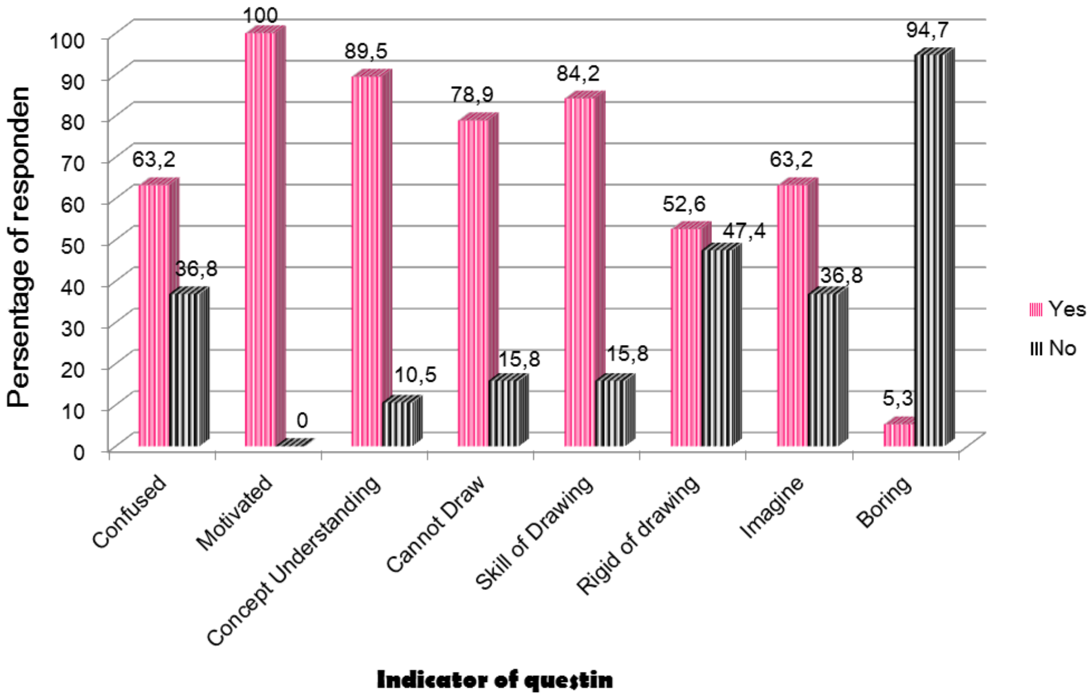


Figure 6. Students' responds to the visual partial learning on biology subject.

Seen from graph 02 data, the average respondent responded positively to the learning that had been experienced. According to students, the applied visual spatial learning was not boring, they were motivated in learning because they were given the freedom to express their drawing ideas, they felt their drawing skills began to increase and were no longer rigid, and helped understanding the concept of biological material. In applying this visual learning, it was better for educators to recognize the students' intelligence so that educators knew what to do in the class so that there was no learning tension, students feel motivated and enthusiastic in learning because visual spatial learning required a relaxed atmosphere while still paying attention to learning ethics. Pangrazi & Beighle (2019) suggested about the application of visual spatial learning, so that the optimal educator needs to reduce pressure and provide a positive atmosphere so that children enjoy the process.

Spatial orientation develops with (Pangrazi & Beighle, 2019), therefore spatial visual skills need to be taught from an early age because visual spatial is one of the learning methods that teaches the ability or training of students' skills especially in the field of biology, by spatial thinking students can explore the imagination supported by concrete objects around it. Metoyer & Bednarz (2017) suggested that spatial thinking as a life skill can be learned in formal education and can be improved through appropriate technology and curriculum. Therefore, in the learning process it is necessary to plan before so that the classroom atmosphere is more conducive, and enjoy so it can create learning by doing.

Conclusion

The teacher can identify the beginning of students' visual spatial intelligence and the assessment was done by looking at the similarity of the image made to the original, from the pictures made can also be seen the concepts mastery of the material being taught. From the results of the image assessment made by students, it was found that students already had visual spatial intelligence but need to be trained and developed through learning, with this visual spatial learning the students' concepts mastery also helps students' understanding of this matter as seen from the results on plant cell material; low score category 60, average 25, high 15., animal cell material low 55, average 10, high 35., plant tissue material low 45, average 10, high 45. Visual spatial learning applied can provide fun learning such as high motivation in the next lesson, understanding of the concept was quite increased, students felt their drawing skills were increasingly trained, and can increase students' imagination in drawing abstract material

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