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Student Spatial Skill Profile Based on Cognitive Style in Solving Mathematical Problems through Mathematical Questions Posing

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Abstract

The purpose of this study is to describe students' spatial skills based on field-dependent and field-independent cognitive styles in solving mathematical problems through mathematical questions posing. This study is a qualitative study. The subjects were 4 students of Mathematics Education at PGRI Jombang University, with details of 2 field-dependent students (S1FD and S2FD) and 2 field-independent students (S3FI and S4FI). The main instrument in this study was the researcher herself, while the supporting instruments were the Student Spatial Skills Test (SSST) sheet and interview guidelines. Based on the data presentation and discussion, it can be concluded that S1FD and S2FD are able to understand horizontal invariance but have not been able to apply it to more complex problems. S1FD and S2FD are able to mention changes in the position of elements in a simple object but not in a complex object. S1FD and S2FD are able to combine objects into more complex configurations. S1FD and S2FD are able to combine two simple objects but have not been able to do so on more complex objects. Finally, S1FD and S2FD are able to combine two simple objects but have not been able to do so on more complex objects. Meanwhile, S3FI and S4FI are able to understand horizontal invariance in more complex problems. S3FI and S4FI are able to mention changes in the position of elements in a complex object. S3FI and S4FI are able to combine objects into simple configurations but not yet in more in-depth ones. S3FI and S4FI are able to combine two complex objects. S3FI and S4FI are able to visualize an environment as a whole from different positions. Thus, S1FD and S2FD are weak in spatial perception, spatial visualization, spatial relations, and spatial orientation. However, they are good in mental rotation. Meanwhile, S3FI and S4FI are good in all components of spatial skills, namely spatial relations, spatial perception, spatial visualization, spatial orientation, and mental rotation. The four subjects solved the questions/problems given by mathematical questions posing.

Keywords: *Spatial Skills, Cognitive Style, mathematical questions posing*.

Profil Keterampilan Spasial Mahasiswa Berdasarkan Gaya Kognitif dalam Menyelesaikan Masalah Matematika melalui Pengajuan Pertanyaan Matematis

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Abstrak

Tujuan penelitian ini adalah untuk mendeskripsikan keterampilan spasial mahasiswa berdasarkan gaya kognitif *field-dependent* dan *field-independent* dalam menyelesaikan masalah matematika melalui pengajuan pertanyaan matematis. Penelitian ini merupakan penelitian kualitatif. Subjek penelitian adalah mahasiswa pendidikan matematika universitas PGRI Jombang sebanyak 4 mahasiswa, dengan rincian 2 mahasiswa *field-dependent* (S1FD dan S2FD) dan2 mahasiswa *field-independent* (S3FI dan S4FI). Instrumen utama dalam penelitian ini adalah peneliti sendiri, sedangkan instrumen pendukung adalah lembar Tes Keterampilan Spasial Mahasiswa (TKSM) dan pedoman wawancara. Berdasarkan paparan data dan pembahasan maka dapat disimpulkan bahwa S1FD dan S2FD mampu memahami invariansi horizontal namun belum dapat mengaplikasikan pada masalah yang lebih kompleks. S1FD dan S2FD mampu menyebutkan perubahan posisi unsur-unsur dalam suatu objek yang sedehana namun tidak dalam suatu objek yang kompleks. S1FD dan S2FD mampu menyatukan objek menjadi konfigurasi yang lebih kompleks. S1FD dan S2FD mampu memadukan dua objek sederhana namun belum mampu pada objek yang lebih kompleks. Terakhir, S1FD dan S2FD mampu memadukan dua objek sederhana namun belum mampu pada objek yang lebih kompleks. Sementara S3FI dan S4FI mampu memahami invariansi horizontal pada masalah yang lebih kompleks. S3FI dan S4FI mampu menyebutkan perubahan posisi unsur-unsur dalam suatu objek yang kompleks. S3FI dan S4FI mampu menyatukan objek menjadi konfigurasi yang sederhana namun belum pada yang lebih mendalam. S3FI dan S4FI mampu memadukan dua objek yang kompleks. S3FI dan S4FI mampu memvisualisasikan suatu lingkungan secara keseluruhan dari posisi yang berbeda. Dengan demikian untuk S1FD dan S2FD lemah dalam persepsi spasial, visualisasi spasial, relasi spasial, dan orientasi spasial. Namun baik dalam rotasi mental. Sementara S3FI dan S4FI baik dalam semua komponen keterampilan spasial, yaitu relasi spasial, persepsi spasial, visualisasi spasial, orientasi spasial, dan rotasi mental. Keempat subjek menyelesaikan soal/masalah yang diberikan melalui pengajuan pertanyaan matematis.

Kata kunci: *Keterampilan Spasial, Gaya Kognitif, Pengajuan Pertanyaan Matematis*.

INTRODUCTION

Spatial skills play an important role in learning mathematics, especially geometry. Hodiyanto explains that spatial skills are a person's ability to understand an object by visualizing it, meaning imagining the object to be understood in two or three dimensions (Lowrie & Jorgensen, 2015; Sutton at all, 2016; Hodiyanto, 2018; Salame & Kabir, 2022). According to Kurniawati, spatial skills are an individual's ability to see and imagine spatial objects by simply drawing pictures of the spatial objects on paper (Yurt & Tünkler,

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2016; Anjarsari, 2018; Herawati & Hariyani, 2024). Spatial skills are a person's ability or accuracy in drawing conclusions based on arguments from a situation concerning shape, location, path, relationships between entities, and relationships between entities and frames of reference (Fikrati, Siswono, & Lukito, 2021; Rahmawati, Dianhar, & Arifin, 2021; Uttal at all, 2024). There are four important spatial skills to master, namely: static intrinsic skills, static extrinsic skills, dynamic intrinsic skills, and dynamic extrinsic skills (Otumfuor & Carr, 2017; Fikrati, 2020; Makamure & Jojo, 2021; Pradana & Sholikhah, 2021).

Based on this explanation, spatial skills play a very important role in Geometry material. The material is given from elementary school to college. Mathematics Education students at University of PGRI Jombang are prospective teachers so they are required to have skills in learning mathematics, one of which is spatial skills. Many factors influence spatial skills, one of which is cognitive style. Cognitive style is a part that needs to be considered in designing learning. As one part that needs to be considered in learning, cognitive style reflects the characteristics of students, in addition to other characteristics such as motivation, attitude, interest, thinking ability, and so on. Cognitive style is a part that needs to be considered in designing learning (Huljannah, Sa'dijah, & Qohar, 2018; Fujita at all 2020). Cognitive style is an individual's characteristic in receiving, storing or using information to respond to a task or responding to various types of environmental situations (Istiqomah, 2020; Atit at all, 2020). Cognitive style is divided into field-dependent cognitive style and field-independent cognitive style. Individuals with FD and FI cognitive styles have differences in the method of processing information. FD individuals tend to be global in analyzing learning situations. They have difficulty breaking information into closed parts, and do not consider items different from their context. FD students usually prefer hands-on learning and tend to be incidental learners in social contexts, and have difficulty using intuition. On the other hand, FI individuals tend to be better at analytical activities. They can solve complex problems, remember information, perceive items as having different characteristics from their context, can generally encode information quickly and accurately, and can perform well on standardized tests (Nurmutia, 2019; Wibowo, 2017).

Uttal, Meadow, Tipton, Hand, Alden, Warren, & Newcombe (2013) describe the

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characteristics of spatial skills: (a) seeing objects, paths, or spatial configurations amidst distracting background information, as characteristics of static intrinsic skills; (b) combining objects into more complex configurations, visualizing and mentally transforming objects, as characteristics of dynamic intrinsic skills; (c) understanding abstract spatial principles; and (d) visualizing an environment as a whole from different positions, as characteristics of dynamic extrinsic skills. Meanwhile, Newcombe & Shipley (2015) describe the characteristics of spatial skills as follows: (a) encoding spatial configurations (or shapes) of objects, taking shapes from overlapping objects or other perceptual information, and identifying spatial regions as constituent categories, as characteristics of static intrinsic skills; (b) changing the spatial encoding of objects, including expansion or reduction in size, rotation, cross-section, folding, bending, breaking, and sliding; accumulating sequences of such changes and visualizing the changes over time and the final product, and relating 2- and 3-dimensional views to each other, as characteristics of dynamic intrinsic skills; (c) encoding the spatial location (or position) of objects relative to other objects or to a frame of reference, including gravity, and aligning location codes of different scales, as characteristics of static extrinsic skills; and (d) changing relationships between objects as one or more of them moves, including the observer (e.g., to maintain a stable representation of the world during navigation and to enable perspective taking), as characteristics of dynamic extrinsic skills.

Cognitive style is a part that needs to be considered in designing learning. Cognitive style as part of a student's learning style that shows how they solve a problem (Tian at all, 2022; Rum & Juandi, 2023). Witkin groups cognitive styles based on the way the global analytical continuum divides 2 groups, namely field-dependent and field-independent cognitive styles. In general, students with the FI cognitive style tend to choose individual learning and do not depend on others. Students with the FI cognitive style also have a high level of independence in observing a stimulus without dependence on lecturers. When given a problem, students with the FI cognitive style will use various strategies in an effort to solve the problem and are able to solve the problem without instructions and guidance from lecturers. While students with the FD cognitive style tend to choose to study in groups and often interact with other students or lecturers. Students with the FD cognitive style are also very dependent on sources of information from lecturers

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(Onyekuru, 2015; Susanto, 2017; Hasbullah & Sajiman, 2020; Sutrisno, Rahayuningsih, & Purwati, 2020). The differences in characteristics of the two cognitive styles are: Field-dependent cognitive style: Has better memory for information. Thinks globally better on learning materials with social material, has better memory for social information, Needs clearly defined structure, goals, and reinforcement. More affected by criticism, Has great difficulty learning unstructured materials, Tends to accept the organization given and is unable to reorganize. May need clearer instructions on how to solve problems. While the field-independent cognitive style: Thinks analytically, may need help focusing attention on materials with social content, May be taught how to use context to understand social information.

Spatial skills are students' thinking abilities, such as reasoning. Masruroh (2016-a) explains that improving students' thinking skills can be done by implementing the mathematical question posing (MQP) learning model. Masruroh (2023) explains that the MQP learning model is a learning model that encourages students to ask mathematical questions. Mathematical questions are questions posed by students based on the information provided. This information takes the form of questions/problems that require students to test a hypothesis. This is in line with questions/problems related to spatial skills. Chiang believes that difficulties in visual spatial skills are the cause of students having problems in learning geometry and are the cause of low achievement in mathematics (Abdullah at all, 2015). Konyalioğlu, Aksu, & Þenel, (2012) reported that difficulties in understanding geometric concepts and solving problems in geometry among students were due to their weaknesses in visual spatial skills. Newcombe and Shipley stated that spatial skills can be defined as reasoning regarding shape, location, path, relationships between entities, and relationships between entities and reference frames (Newcombe, & Shipley, 2015; Mustofa at all 2024). Learning methods and cognitive styles can improve mathematics learning outcomes (Wibowo, 2017; Tambi, Murtadho, & Rafli, 2021). There was an influence of cognitive style on students' mathematical problem-solving abilities (Mishra, Kanoujiya, & Yadav, 2017; Udiyono & Yuwono, 2018; Bakar & Ali, 2018; Nurmutia, 2019; Cahyono, Rohman, & Setyawati, 2022; Utomo, 2022). Masruroh (2016-b) explains that the quality of mathematical questions asked by students is in accordance with their thinking abilities.

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RESEARCH METHODS

This research is a qualitative research with descriptive method. The purpose of this study is to describe the Spatial Skills Profile of Mathematics Education Students at PGRI Jombang University in terms of Field-Dependent and Field-Independent Cognitive Styles. The prospective subjects of this study are 22 second-semester mathematics education students at PGRI Jombang University. The research subjects are 4 students with details of 2 field-independent students and 2 field-dependent students. The selection of subjects is done purposively, namely by considering the activeness of students in learning, in addition the researcher will also consider good oral communication skills to facilitate the interview process. The main instrument in this study is the researcher himself, while the supporting instruments are the Group Embedded Figures Test (GEFT) sheet, the Student Spatial Skills Test (SSST) sheet, and interview guidelines. This research method is a test and interview. The criteria for data validity and how to check it include credibility using time triangulation, so the researcher will conduct at least 2 times each of the Student Spatial Skills tests and interviews. Data analysis was carried out through three stages: data reduction, data presentation, and drawing conclusions (Sugiyono 2015).

Tabel 2.1 Components and Indicators of Spatial Skills

Spatial Skills	Components	Skills measured	Indicator
Intrinsic Static	Spatial Relations	Seeing objects, paths, or spatial configurations amidst distracting background information	Finding other hidden shapes in more complex/complicated shapes
Intrinsic Dynamic	Mental rotation and spatial visualization	• Combining objects into more complex configurations • Visualizing and mentally transforming objects, often from 2-dimensional to 3-dimensional, or vice versa • Rotating 2-dimensional or 3-dimensional objects	• Combine objects into more complex configurations, • Visualize and mentally transform objects • Rotate objects and reveal changes in the position of elements within an object
Extrinsic Static	Spatial perception	Understanding abstract spatial principles, such as horizontal invariance or vertical invariance	Determining spatial relationships in relation to one's own body orientation
Extrinsic Dynamic	Spatial orientation	Visualize an environment as a whole from different positions	Drawing the shape of an object from different perspectives

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RESULTS AND DISCUSSION

Four research subjects with different cognitive styles were required in this study. Two subjects each had a field independent (FI) cognitive style and two subjects had a field dependent (FD) cognitive style. These subjects were obtained based on the results of the Group Embedded Figures Test (GEFT). The GEFT test is a test used to determine the type of cognitive style of students. Susanto (2017) stated that the GEFT test is a valid test and can also be used in research. The GEFT test instrument consists of 25 complex images divided into three stages. The first stage is a practice stage consisting of 7 images. The second and third stages each consist of 9 images. This part is the examination and assessment stage. In this GEFT test, there are 8 simple images named A, B, C, D, E, F, G and H that must be found in the 25 images in the question by putting a bold line on the image. Each number is given a score of 1 for students who answer correctly and a score of 0 for students who answer incorrectly. The scores calculated are only the second and third parts, because the first part is intended as practice. The time given to complete the GEFT test is 25 minutes.

Data obtained from the GEFT test were analyzed using cognitive style scoring categories. Correct answers were scored 1, while incorrect answers were scored 0. Thus, the highest possible score was 18 and the lowest score was 0 (Rassaei & Ravand, 2024). The scoring guidelines used were as follows:

Table 2. Cognitive Style Categories

Score (s)	Cognitive Style Type	Total
$0 \leq s \leq 9$	*Field dependent*	17
$9 < s \leq 18$	*Field independent*	15

Based on Table 2, a total of 22 prospective subjects were obtained. In detail, there were 13 prospective subjects with a field-dependent cognitive style, while there were 9 prospective subjects with a field-independent cognitive style. Furthermore, through purposive sampling techniques, four research subjects were determined, each consisting of two students (Sugiyono, 2015; Cahyono, Rohman, & Setyawati, 2022). Subjects with a field-dependent cognitive style are hereafter referred to as S1FD and S2FD. Subjects with a field-independent cognitive style are hereafter referred to as S3FI and S4FI. Afterward, the four subjects were given a Spatial Skills test and in-depth interviews to

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explore their Spatial Skill profiles.

The Student Spatial Skills Test (SSST) instrument was used to answer the research problem, namely how the spatial skills of mathematics education students at PGRI Jombang University with field-dependent and field-independent cognitive styles. This instrument consists of 25 questions. 5 questions related to Spatial Perception, namely questions number 1, 12, 17, 23, and 25. 5 questions related to Visualization, namely questions number 2, 7, 13, 14, and 18. 5 questions related to Mental Rotation, namely questions number 3, 4, 9, 15, 19. 5 questions related to Spatial Relations, namely questions number 8, 10, 16, 20, and 22. And 5 questions related to Spatial Orientation, namely questions number 5, 6, 11, 21, and 24. Fikrati (2020) stated that SSST is a valid test and can also be used in research. This test was conducted in two stages because it met the data validity criteria. The first stage of the Student Spatial Skills Test was called SSST 1. The second stage of the Student Spatial Skills Test was called SSST 2. After the SSST was completed, interviews were conducted for each stage. The following are the SSST results for the four subjects.

Table 3. List of Research Subjects Based on Cognitive Style Categories

No.	Spatial Skills Score	Subject Code	Cognitive Style
1	8 and 10	S1FD and S2FD	Field dependent
2	20 and 23	S3FI and S4FI	Field independent

Based on Table 3, it was obtained that the spatial skill score of S1FD was 8, S2FD was 10, S3FI was 20, and S4FI was 23. Based on the answers and interview results, it showed that the four subjects were able to master spatial skills in the simple level of Spatial Perception category. As Newcombe & Shipley (2015) explained, the indicator of Spatial Perception is understanding abstract spatial principles, such as horizontal invariance or vertical invariance. However, there are differences in spatial skills in the complex level of Spatial Perception category by subjects with field-dependent and field-independent cognitive styles. The following is an explanation of these differences.

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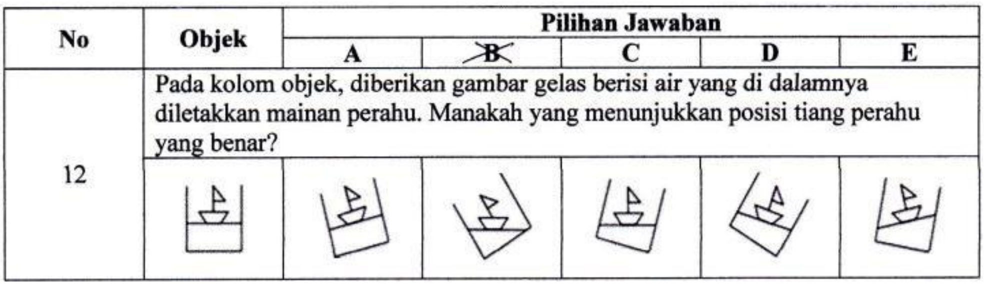

No	Objek	Pilihan Jawaban				
		A	~~B~~	C	D	E
12	Pada kolom objek, diberikan gambar gelas berisi air yang di dalamnya diletakkan mainan perahu. Manakah yang menunjukkan posisi tiang perahu yang benar?					

Figure 1. Subjects' Responses with a Field-Dependent Cognitive Style to Question Items 12.

Figure 1 shows that subjects with a field-dependent cognitive style were unable to answer the question correctly. The question asked the subjects to determine the correct position of a boat mast when a glass of water changes position. To further explore the subjects' answers, interviews were conducted. The following is an excerpt from the interview related to Figure 1.

Table 4. Excerpts from Interview Results of Subjects with a Field-Dependent Cognitive Style to Question Items 12.

Interview Sequence		Researcher Questions and Subject Answers
Researcher	:	What image is in the object column?
S1FD	:	It's a picture of water and a boat in a glass with a toy boat inside.
Researcher		What does question 12 mean?
S1FD		Find the correct position of the boat's mast.
Researcher	:	What did you do to get the answer?
S1FD	:	I Imagine the position of the boat's mast in the glass, changing its position.
Researcher	:	Why is that the answer?
S1FD	:	Because if the glass is moved, its position remains straight and horizontal, while the mast will follow its movement.
Researcher	:	Are there any other factors that support your answer?
S1FD	:	None.

Based on Table 4, it can be seen that S1FD understands that the question asks to determine the correct position of the boat mast when the glass filled with water changes position. S1FD understands that the position of the water surface remains horizontal even though the position of the glass changes, but the position of the boat mast follows the position of the glass. Therefore, the answer of the subject with a field-dependent cognitive style is less accurate. Based on Hodiyanto (2018), it can be concluded that S1FD is able to understand horizontal invariance or vertical invariance in a simple way but has not been able to apply it to more complex problems. Meanwhile, subjects with a field-independent cognitive style are able to answer correctly. The following is an example of

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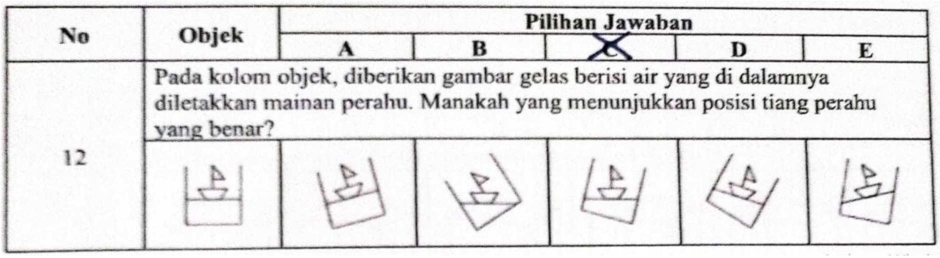
a subject's answer with a field-independent cognitive style.



No	Objek	Pilihan Jawaban				
		A	B	~~C~~	D	E
12	Pada kolom objek, diberikan gambar gelas berisi air yang di dalamnya diletakkan mainan perahu. Manakah yang menunjukkan posisi tiang perahu yang benar?					

Figure 2. Subjects' Responses with a Field-Independent Cognitive Style to Question Items 12.

Figure 2 shows that subjects with a field-dependent cognitive style were able to answer correctly. The question asked the subjects to determine the correct position of a boat mast when a glass of water changes position. To further explore the subjects' answers, interviews were conducted. The following is an excerpt from the interview related to Figure 2.

Table 5. Excerpts from Interview Results of Subjects with a Field-Independent Cognitive Style to Question Items 12.

Interview Sequence		Researcher Questions and Subject Answers
Researcher	:	What image is in the object column?
S4FI	:	Question 12 shows a picture of water in a glass with a toy boat inside.
Researcher		What does question 12 mean?
S4FI		Find the correct position of the boat's mast.
Researcher	:	What did you do to get the answer?
S4FI	:	Imagine the water in the glass in different positions and the position of the boat's mast.
Researcher	:	Why is that the answer?
S4FI	:	Because if the water container is moved, the position of the water surface remains straight horizontally but the position of the boat is straight vertically to the water surface so the position of the boat mast is also straight vertically to the water surface.
Researcher	:	Are there any other factors that support your answer?
S4FI	:	Yes.
Researcher	:	Please state them!
S4FI	:	Water always conforms to the shape of its container.

Based on Table 4, it is found that S4FI understands that the question asks to determine the correct position of the boat mast when the glass filled with water experiences a change in position. S4FI understands that the position of the water surface remains straight horizontally even though the position of the glass changes, but the position of the boat is straight vertically to the water surface so the position of the boat mast is also straight vertically to the water surface. So the answer of the subject with the field-Independent cognitive style is correct. When reviewed by Hodiyanto (2018), it can

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be concluded that S4FI is able to understand horizontal invariance or vertical invariance simply and can also apply it to more complex problems.

Based on the results of the Student Spatial Skills test and interviews, it was obtained that S1FD and S2FID were able to answer 2 questions about spatial perception, namely on questions number 1 and 17. This shows that S1FD and S2FD are able to understand horizontal invariance but have not been able to apply it to more complex problems (Lowrie & Jorgensen, 2015; Hodiyanto, 2018). S1FD and S2FD were able to answer 2 questions about spatial visualization, namely on questions number 2 and 7. This shows that S1FD and S2FD are able to mention changes in the position of elements in a simple object but not in a complex object (Anjarsari, 2018; Herawati & Hariyani, 2024). S1FD and S2FD were able to answer 2 mental rotation questions, namely on questions number 3 and 4. This shows that S1FD and S2FD are able to combine objects into more complex configurations (Fikrati, Siswono, & Lukito, 2021; Rahmawati, Dianhar, & Arifin, 2021). S1FD was able to answer 1 question about spatial relations, namely on question number 10. S1FD was able to answer 2 questions about spatial relations, namely on questions number 10 and 16. This shows that S1FD and S2FD are able to combine two simple objects but are not yet able to do more complex objects (Fikrati, 2020; Makamure & Jojo, 2021). Finally, S1FD was able to answer 1 question about spatial orientation, namely on question number 5. S1FD was able to answer 2 questions about spatial relations, namely on questions number 5 and 6. This shows that S1FD and S2FD are able to combine two simple objects but are not yet able to do more complex objects (Fikrati, 2020; Makamure & Jojo, 2021).

Meanwhile, S3FI was able to answer 4 questions about spatial perception, namely on questions number 1, 17, 23, and 25. S4FI was able to answer all questions about spatial perception or as many as 5 numbers, namely on questions number 1, 12, 17, 23, and 25. S3FI and S4FI were able to understand horizontal invariance in more complex problems (Lowrie & Jorgensen, 2015; Hodiyanto, 2018). S3FI was able to answer 4 questions about spatial visualization, namely on questions number 2, 7, 13, and 18. S4FI was able to answer all questions about spatial visualization or as many as 5 numbers, namely on questions number 2, 7, 13, 14, and 18. S3FI and S4FI were able to mention changes in the position of elements in a complex object (Anjarsari, 2018; Herawati & Hariyani,

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2024). S3FI and S4FI were able to answer 4 questions about mental rotation, namely on questions number 3, 4, 9, and 15. S3FI and S4FI were able to combine objects into simple configurations but not yet in more in-depth ones (Fikrati, Siswono, & Lukito, 2021; Rahmawati, Dianhar, & Arifin, 2021). S3FI and S4FI were able to answer 4 questions about spatial relations, namely on questions number 8, 10, 16, and 22. S3FI and S4FI were able to combine two complex objects. Finally, S3FI was able to answer 4 questions about spatial orientation, namely on questions number 5, 6, 11, and 24. S4FI was able to answer all questions about spatial orientation or as many as 5 numbers, namely on questions number 5, 6, 11, 21, and 24. S3FI and S4FI were able to visualize an environment as a whole from different positions (Fikrati, 2020; Makamure & Jojo, 2021). Thus, S1FD and S2FD were weak in spatial perception, spatial visualization, spatial relations, and spatial orientation. However, they were good in mental rotation. Meanwhile, S3FI and S4FI were good in all components of spatial skills, namely spatial relations, spatial perception, spatial visualization, spatial orientation, and mental rotation.

CONCLUSION

Based on the data presentation and discussion, it can be concluded that S1FD and S2FD are able to understand horizontal invariance but have not been able to apply it to more complex problems. S1FD and S2FD are able to mention changes in the position of elements in a simple object but not in a complex object. S1FD and S2FD are able to combine objects into more complex configurations. S1FD and S2FD are able to combine two simple objects but have not been able to do more complex objects. Finally, S1FD and S2FD are able to combine two simple objects but have not been able to do more complex objects. Meanwhile, S3FI and S4FI are able to understand horizontal invariance in more complex problems. S3FI and S4FI are able to mention changes in the position of elements in a complex object. S3FI and S4FI are able to combine objects into simple configurations but have not been able to do more in-depth ones. S3FI and S4FI are able to combine two complex objects. S3FI and S4FI are able to visualize an environment as a whole from different positions. Thus, S1FD and S2FD are weak in spatial perception, spatial visualization, spatial relations, and spatial orientation. However, they are good at mental rotation. Meanwhile, S3FI and S4FI are good at all components of spatial skills: spatial relations, spatial perception, spatial visualization, spatial orientation, and mental rotation.

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REFERENCES

Abdullah, A. H. B, Wahab, R. A., Abu. M. S. B, Mokhtar, M. B., & Atan, N. A. B. (2015). A Case Study on Visual Spatial Skills and Level of Geometric Thinking in Learning 3D Geometry Among High Achievers. *Man In India*, 96 (1-2): 489-499. http://eprints.utm.my/71265/

Anjarsari, E. (2018). Mengembangkan Kemampuan Spasial Siswa Melalui Pendekatan Saintifik dalam Pembelajaran Matematika Reforma. *Jurnal Pendidikan dan Pembelajaran* Vol. 7 No. 2 (2018) p-ISSN: 2503-1228; e-ISSN: 2621-4172. https://doi.org/10.30736/rfma.v7i2.77

Atit, K., Power, J.R., Veurink, N., Uttal, D.H., Sorby, S., Panther, G., Msall, C., Fiorella, L., & Carr, M. (2020). Examining the Role of Spatial Skills and Mathematics Motivation on Middle School Mathematics Achievement. *International Journal of STEM Education*. https://doi.org/10.1186/s40594-020-00234-3

Bakar, Z. A. & Ali, R. (2018). Interchangeable Concept of Cognitive Styles and Learning Styles: a Conceptual Analysis. *Journal of Education and Learning* (*EduLearn*). Vol.12, No.2, May 2018, pp. 179-187. https://doi.org/10.11591/edulearn.v12i2.6573

Cahyono, B., Rohman, A. A., & Setyawati, R. D. (2022). Critical Thinking of Prospective Teachers in Solving Math Problems in Terms of Learning Styles. *Phenomenon: Jurnal Pendidikan MIPA*, *12*(2), 226–241. https://doi.org/10.21580/phen.2022.12.2.13349

Fikrati, A.N. (2020). *Keterampilan Spasial Siswa SMA dalam Menyelesaikan Masalah Geometri Ditinjau dari Perbedaan Gender*. Disertasi tidak dipublikasikan. Surabaya: Universitas Negeri Surabaya.

Fikrati, A.N., Siswono, T.Y.E., & Lukito, A. (2021). Dynamic Geometry Environment to Enhance High School Students Spatial Skill: A Study Based on Sex and Gender Diversities Perspective. *The New educational review* 2021 vol. 63 no. 1. https://doi.org/10.15804/tner.21.63.1.09

Fujita, T., Kondo, Y., Kumakura, H., Kunimune, S., & Jones, K. (2020). Spatial reasoning skills about 2D representations of 3D geometrical shapes in grades 4

University of PGRI Jombang
Email: faridatulm.upjb@gmail.com

ISSN: 2088-7868, e-ISSN 2502–5708

to 9. *Mathematics Education Research Journal*, 32, 235-255. https://doi.org/10.1007/s13394-020- 00335-w

Hasbullah & Sajiman, S.U. (2020). The Differences of Cognitive Style Fields-Independent and Dependent on Students' Mathematical Problem Solving Abilities. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*. Volume 9, No. 2, 2020, 387-394. https://doi.org/10.24127/ajpm.v9i2.2778

Herawati & Hariyani, M. (2024). Spatial Thinking Ability in Elementary School. *PIONIR: Jurnal Pendidikan*. VOLUME 13, No. 1, 2024, Hal. 157 – 168. https://doi.org/10.22373/pjp.v13i1.23002

Hodiyanto, H. (2018). Kemampuan spasial sebagai prediktor terhadap prestasi belajar geometri mahasiswa. *Jurnal Mercumatika*: *Jurnal Penelitian Matematika dan Pendidikan Matematika*. ISSN: 2548-1819. Vol. 2, No 2, April 2018, pp. 59-65. https://doi.org/10.26486/jm.v2i2.364

Huljannah, M., Sa'dijah, C., dan Qohar, A. (2018). Profil Berpikir Kreatif Matematis Mahasiswa Pendidikan Guru Sekolah Dasar. *Jurnal Pendidikan*: *Teori, Penelitian, dan Pengembangan*. Volume: 3 Nomor: 11 Bulan November Tahun 2018. Halaman: 1428—1433. http://dx.doi.org/10.17977/jptpp.v3i11.11730

Istiqomah. (2020). *Profil Berfikir Kreatif Siswa SMA dalam Menyelesaikan Masalah Peluang Ditinjau dari Kemampuan Matematika*. Tesis Magister pada STKIP PGRI Jombang.

Kho, Ronaldo. (2011). *Penjenjangan Penalaran Visuospasial Siswa dalam Menyelesaikan Masalah Geometri*. Disertasi Doktor, Universitas Negeri Surabaya.

Konyalioğlu, A. C., Aksu, Z., & Þenel, E. Ö. (2012). The preference of visualization in teaching and learning absolute value. *International Journal of Mathematical Education in Science and Technology*, 43(5), 613-626. https://doi.org/10.1080/0020739X.2011.633627

Lowrie, T., & Jorgensen, R. (2015). Pre-service teachers' mathematics content knowledge: Implications for how mathematics is taught in higher education. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, 35(4), 202-215. https://doi.org/10.1093/teamat/hrv008

University of PGRI Jombang
Email: faridatulm.upjb@gmail.com

ISSN: 2088-7868, e-ISSN 2502–5708

Makamure, C. & Jojo, Z.M. (2021). Visual-Spatial Skills and Mathematics Content Conceptualisation for Pre-Service Teachers. *Indonesian Journal of Science and Mathematics Education*. 04 (3) (2021) 223-241. https://doi.org/10.24042/ijsme.v4i2.9842

Masruroh, Faridatul. (2016-a). *Pengembangan Model Pembelajaran Pengajuan Pertanyaan Matematis (PPM) untuk Meningkatkan Penalaran Matematis siswa*. Malang: Disertasi, PPs. UM.

Masruroh, Faridatul. (2016-b). Analisis Kualitas Pertanyaan Matematis Mahasiswa Berdasarkan Kemampuan Penalarannya. *Edumath*, Vol. 3 Nomor 1. Mei-Oktober 2016. https://ejournal.stkipjb.ac.id/index.php/math/article/view/404

Masruroh, Faridatul. (2023). *Model Pembelajaran Pengajuan Pertanyaan Matematis (PPM) untuk Meningkatkan Penalaran Matematis siswa*. Jombang: Lima Aksara. Mishra, A., Kanoujiya, J., & Yadav, S. (2017). Systematic Review of Cognitive Style, Its Approaches and Cultural Research. *The International Journal of Indian Psychology*. Volume 4. Issue 4. https://doi.org/10.25215/0404.058

Mustofa, H. A., Zain, Z. A., Tsania, H., Azman, M. N. A., Marmoah, S., & Masfuah, S. (2024). Analysis of Students' Conceptions Based on Cognitive Style on Newton's Law Understanding. *JPII*.13 (2) (2024) 301-312. https://doi.org/10.15294/mx0v4952

Newcombe, N.S., and Shipley, T.F. (2015). *Thinking about Spatial Thinking: New Typology, New Assessments*, in Gero, J.S., ed., Studying Visual and Spatial Reasoning for Design Creativity. Netherlands, Springer, p. 179–192, https://doi.org/10.1007/978-94-017-9297-4_10.

Nurmutia, H.E. (2019). Pengaruh Gaya Kognitif terhadap Kemampuan Pemecahan Masalah Matematis Siswa. *EDUMATIKA: Jurnal Riset Pendidikan Matematika*, Volume 2, Nomor 2, November 2019. https://doi.org/10.32939/ejrpm.v2i1.443

Onyekuru, B. U. (2015). Field Dependence-Field Independence Cognitive Style, Gender, Career Choice and Academic Achievement of Secondary School Students in Emohua Local Government Area of Rivers State. *Journal of Education and Practice,* 6(10), 76-85.

University of PGRI Jombang
Email: faridatulm.upjb@gmail.com

ISSN: 2088-7868, e-ISSN 2502–5708

https://www.iiste.org/Journals/index.php/JEP/article/view/21440

Otumfuor, B. A., & Carr, M. (2017). Teacher spatial skills are linked to differences in geometry instruction. *British Journal of Educational Psychology*, 87(4), 683-699. https://doi.org/10.1111/bjep.12172

Pradana, L.N. & Sholikhah, O.H. (2021). Connecting Spatial Reasoning Process to Geometric Problem. *Profesi Pendidikan Dasar*. Vol. 8, No. 2. http://dx.doi.org/10.23917/ppd.v7i1.9652

Rahmawati, Y., Dianhar, H., & Arifin, F. (2021). Analysing Students' Spatial Abilities in Chemistry Learning Using 3D Virtual Representation. *Educ. Sci*. 11, 185. https://doi.org/10.3390/educsci11040185

Rassaei, E., & Ravand, H. (2024). Immediate versus delayed prompts, field dependence and independence cognitive style and L2 development. 62(2), 927–952. https://doi.org/ 10.1515/iral-2022-0137

Rum, A. M. & Juandi, D. (2023). Students' Mathematical Literacy Viewed from Cognitive Style: Systematic Literature Review. *Jambura J. Math. Educ*., vol. 4, no. 1, pp.1-10, 2023. https://doi.org/10.34312/jmathedu.v4i1.17438

Salame, I. I., & Kabir, S. A. (2022). Examining Students' Spatial Ability and Its Impact on the Learning of Stereochemistry. *Interdisciplinary Journal of Environmental and Science Education*, 18(4), e2288. https://doi.org/10.21601/ijese/12099

Sugiyono. (2015). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung, Indonesia: Alfabeta.

Susanto, H.A. (2017). *Pemahaman Pemecahan Masalah Berdasar Gaya Kognitif*. Yogyakarta: Deepublish.

Sutrisno, Rahayuningsih, D., & Purwati, H. (2020). The Impact of Cognitive Style-based Learning Models on Students' Problem-Solving Abilities. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *5*(2), 297-306. https://doi.org/10.24042/tadris.v5i2.5873

Sutton, K., Williams, A., & Tremain, D. 2016. "University entry score Is it a consideration for spatial performance in architecture design students?". *Journal of Engineering, Design and Technology*, 14(2), https://doi.org/10.1108/JEDT-10-2013-0073

University of PGRI Jombang
Email: faridatulm.upjb@gmail.com

ISSN: 2088-7868, e-ISSN 2502–5708

Tambi, T., Murtadho, F., & Rafli, Z. (2021). The effect of learning strategy and cognitive Style on Students' Narrative Writing Ability. *Linguistics and Culture Review*, 5(S3), 1241- 1249. https://doi.org/10.21744/lingcure.v5nS3.1835

Tian, J., Ren, K., Newcombe, N. S., Weinraub, M., Vandell, D. L., & Gunderson, E. A. (2022). Tracing the origins of the STEM gender gap: The contribution of childhood spatial skills. Developmental Science, 26, Article e13302. https://doi.org/10.1111/desc.13302

Udiyono & Yuwono, M. R. (2018). The Correlation between Cognitive Style and Students' Learning Achievement on Geometry Subject. Infinity, 7 (1), 35-44. https://doi.org/10.22460/infinity.v7i1.p35-44

Utomo, E. S. (2022). Analysis of the Mathematical Visualization Process of Female Students in Solving Contextual Problems Based on Cognitive Style. *Phenomenon: Jurnal Pendidikan MIPA*, *12*(1), 31–47. https://doi.org/10.21580/phen.2022.12.1.10850

Uttal, D.H., Meadow, N.G., Tipton, E., Hand, L.L., Alden, A.R., Warren, C., and Newcombe, N.S. (2013). *The Malleability of Spatial Skills: A Meta-Analysis of Training Studies*. Psychological Bulletin, v. 139, p. 352–402, https://doi.org/10.1037/a0028446.

Uttal, D. H., McKee, K., Simms, N., Hegarty, M., and Newcombe, N. S. (2024). How can we best assess spatial skills? Practical and conceptual challenges. *Journal of Intelligence*, 12(8). https://doi.org/10. 3390/jintelligence12010008

Wibowo, S. (2017). Metode Pembelajaran dan Gaya Kognitif dalam Meningkatkan Hasil Belajar Matematika. *JPPP | Jurnal Penelitian dan Penilaian Pendidikan*, 2017: Januari – Juni, Volume 2, Nomor 1, (125-139). https://doi.org/10.22236/jppp.v2i1.1272

Yurt, E., & Tünkler, V. (2016). A study on the spatial abilities of prospective social studies teachers: A mixed method research. *Educational Sciences: Theory & Practice*, 16(3), 965-986. https://doi.org/10.12738 /estp.2016.3.0324

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ISSN: 2088-7868, e-ISSN 2502–5708