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REVIEW ARTICLE

The Analysis of Secondary School Students' Transition Situations in Multiple Representations

Mehmet Altan Kurnaz[1]*, Nezihe Gökçen Bayri[2]

[1]Department of Mathematics and Science Education, Kastamonu University, Turkey, [2]Graduate School of Natural and Applied Science, Kastamonu University, Turkey

***Corresponding Author:** altan.kurnaz@gmail.com

ABSTRACT

In this article, the relationships between students' personal relationship to the concept of pressure and teaching conditions of this concept were investigated in terms of the Anthropological Theory of Didactics. To determine these complex relationships, first an institutional analysis was conducted, and in this same manner, the textbook has been analyzed to uncover the institutional eelationship to the concept of pressure, and second, an achievement test has been used to gather data to uncover personal relationship to concept of pressure. 348 8th-grade students who successfully completed the pressure topic in their science classes participated in this study. The gathered data were analyzed in a descriptive and qualitative way. The results of this study emphasize the relationship between the teaching conditions and the students' understanding of pressure and support the need for multiple representations to teach effectively the pressure concept.

KEY WORDS: pressure; transitions in representations; anthropological theory of didactics; secondary education

INTRODUCTION

As a consequence of the developments in communication and informatics, it is now expected for individuals to use all sorts of communication tools effectively, to have information and research literacy, critical thinking skills, and information attainability (Barnett et al., 2007). In this sense, in order for individuals to understand new information and make inferences - verbal, textual, visual, symbolic, graphical, algebraic, etc., - it is required for them to be able to read supplied information in multiple formats. In this context, in the curricula, there are educational requirements for students to record and process the data in different formats such as creating and presenting a model. Recording and processing data and information in different formats and then moving from these to modeling and presenting require the ability to use different forms of knowledge and make transitions between them (Hiebert and Carpenter, 1992; Duval, 1995; Piez and Voxman, 1997; Even, 1998), and these skills are closely related to learning the knowledge (Duval, 1993; 1995).

The ability of the students to learn new knowledge or a new concept and then to use it effectively in a different representation of knowledge/concept has been an important research field. In these studies, the ability of students to understand and/or use effectively knowledge/concepts in different representations has been investigated along with highlighting potential obstacles to this understanding and/or usage. According to the relevant literature, identified primary possible causes of deficiencies/alternative ideas are poor learning environment, student's earlier daily life experience or textbooks (Leite, 1999; Sözbilir, 2003; De Berg, 2008), intangible nature of the knowledge/concept (Baser and Çataloğlu, 2005), or cultural notions (Ericson, 1979; Harrison et al., 1999; Lubben et al., 1999). The anthropological theory of didactics proposed by Chevallard (1992) might be appropriate to examine the effects of the learning environment or course books - related to effective use of different presentations of knowledge - on learning systematically. This theory is built on three basic concepts: Person (X), institution (I), and object (O).

In anthropological theory, I, is the layout, teaching individuals unique ideas and knowledge and has unique methods, i.e., school, family, and physics course. X describes each person in the study or work stages, and O describes a topic or concept/knowledge, i.e., acceleration, force, logarithms, and functions. $R_I(O)$ describes the concepts such as: What to do with the knowledge, knowledge serves which purpose, how knowledge is processed, or the institutional relationship with knowledge. Therefore, knowledge of an individual about an object based on an institution is defined as "R(X,O): X's personal relationship to O in I." According to the theory, an individual's learning and hence their deficiencies/alternative ideas can change and this is determined under the terms of the institutional relationship.

THEORETICAL FRAMEWORK

Pressure is one of the fundamental concepts of physics that is experienced in daily life, dealing with an interdisciplinary nature, and one of the concepts constituting the top educational environment (Ünal, 2005). Pressure, despite being one of the basic concepts taught in schools, is one of the basic concepts that students have difficulty learning and as a result develop several alternative ideas (Tytler, 1998; Psillos and Kariotoglou, 1999; Şahin, 2010), Pressure and student learning about pressure have been the subject of research. This research can be classified into two categories: (I) Misconceptions and/or learning difficulties on pressure (Sere, 1982; Kariotoglou and Psillos, 1993; Tytler, 1998; Psillos and Kariotoglou, 1999; Taylor and Lucas, 2000; Basca and Grotzer, 2001; Besson, 2004; Önen, 2005) and (II) alternative approaches to teach pressure (Basca and Grotzer, 2001; She, 2005; Önen, 2005; Şahin, 2010; Şahin and Çepni, 2012).

In the studies given above, the results highlight that students do have conceptual learning deficiencies/limitations, and to eliminate these implementation of alternative/effective teaching practices are recommended. However, in those studies, students' usage of data/knowledge in different formats on the pressure concept and their ability to perform transitions between the forms has not been evaluated sufficiently. In addition, as an institution, during science class (I), as well as verbal and mathematical data sheets: Tables, graphs, and figures/images that are contained by related data sheets (O) are frequently used for the examination of learners (X) (Arslan, 2009).

Natural language representations could be thought as a semiotic system for the representation of reality (Vinner, 1991). In fact, data sheets/images such as mathematical symbol/equality, tables, graphs, and figures/images are different semiotic systems, and at least one of them must be used in the presentation of information (Arcavi, 2003; Arslan, 2009). While the statement "Pressure (P) is the force (F) applied perpendicular to the surface of an object per unit area (S)" is an example of natural language representation, "P=F/S" is an example of symbolic representation. Figure 1 is an example of the visual representation of the previous statement.

In other words, in any learning environment, different representations related to information can be used simultaneously and they reflect the institutional relationship. Reflection of the institutional relationship can be seen in the textbooks in a lesson, and the quality of the types of representations used in the textbooks should be qualified for meaningful learning. According to Arslan (2005), when $R_I(O)$ is determined regarding the concept, textbooks are indispensable for detailed institutional relationship analysis. Here, it can be said that representations related to pressure

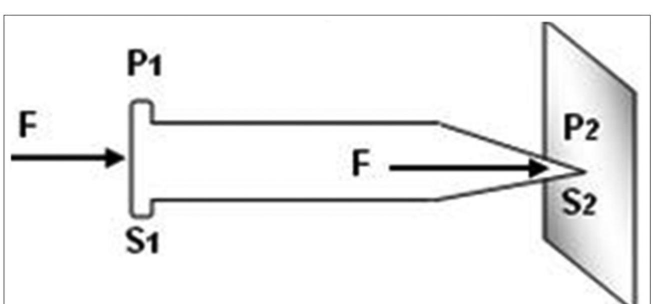


Figure 1: Visual representation of pressure

issues used in a science lesson (I) defines the $R_I(O)$, and $R_I(O)$ could be deducted by the students moving from the textbooks. If we take into consideration that R(X, O) is developed into $R_I(O)$, within the scope of the assessment of student learning, the students' understanding in different semiotic systems must be taken into account on the basis of the $R_I(O)$.

PURPOSE OF THE RESEARCH

Moving from the fact that using different representations of a concept and transitions between them are closely related to conceptualization of the learner, the aim of this study was to find answers to the following two questions:

i. In science textbooks, how the types of representations are related to the pressure topic and the nature of the transition between them [R_I (O)]?
ii. Are the students able to successfully transition between representation types that are determined within the framework of the institutional relationship [R(X, O)]?

METHODOLOGY

General Background of Research

The study was carried out as a two-staged descriptive research approach. In the first stage, the science textbooks that are commonly used in Turkey were analyzed, in terms of the theoretical framework given above, on the basis of the research topic that students who participated in this study may experience. In addition, institutional relationships were determined in terms of the representations and the quality of transitions between the representations. Thus, preliminary data for the second stage of the study were obtained. In the second stage, students' proficiencies to switch between types of representation that were identified related to the pressure topic were examined.

Participants

A total of 348 8th-grade students wereparticipated in this study. Students participating in this study were all located in a city in the Black Sea Region of Turkey. These students were selected through purposive sampling strategies. First, they all completed their education related to the pressure topic in their science classes. Second, they were all successful in their achievement tests that consisted of open-ended questions supplied by their teachers.

Instrument

Proficiencies of the students on making transitions between representation types related to the pressure topic were examined with the reference to an achievement test. Placing the representation types in the achievement test (verbal/text, pictorial, and table) was decided according to the textbook analysis. Achievement test was examined in a pilot study conducted with 60 students from the points of applicability and readability aspects. The results of the pilot study were examined in accordance with the expert opinion, and the final shape of the study's test was determined [Appendix 1].

Data Analysis

The science textbooks were examined through document analysis. In this process, the types of representations were classified as follows: Open, semi-open, or hidden/implicit. Open transition explicitly stated the direct association (...as it can be seen in the next/following representation...) between the two representation types. Hidden/implicit transitions made indirect associations between the two representation types, and the relationship between them must be established by the reader. Semi-open transitions made indirect associations between the two representation types too, but there are also clear directions that describe the other in the type of representation.

Analysis of the student verbal responses was carried according to a prepared rubric [Table 1] that was developed by Abraham et al. (1994) and has a history of use in research both internationally and in Turkey (Westbrook and Marek, 1992; Çalık and Ayas, 2005). Answers in representation types in terms of tables and figures were configured to be analyzed appropriately according to Abraham et al. (1994) rubric [Table 1]. All answers were compared with the criteria in the rubric, and then, the responses are classified as unanswered/meaningless, false, partially true with a fault, and partially true without a fault or true.

RESULTS

Results are presented in relation to the pressure topic, the institutional relationship, and the individual relationship. As such, results are grouped as representation types used in textbooks and their transition qualifications and status of students' ability to make transitions between representation types.

Representation Types Used in Textbooks and Their Transition Qualifications

Besides verbal explanation/representations related to the concept of pressure in the textbook, it was determined that 59 notations included images and tables. 51 (86.4%) of these were visual representation type, and 8 (13.6%) were table representation type. 34 (57.6 %) of the 59 were transitions from the text representation type to the visual representation type. 17 (28.8%) were from visual representation type to the text representation type. Moreover, the remaining 8 (13.6%) were from text representation type to the table representation type. When transitions were evaluated in terms of type, 35 (59.3%) transitions were open (between text and visual representation types), the other 24 (40.7%) transitions were semi-open, and none of them were hidden/implicit.

Status of Students' Ability to Make Transitions between Representation Types

Considering the representation types used in the framework of institutional relationship, the status of students' ability to perform transitions between representation types was examined. This was done to address the second research question.

The transition from text representation type to visual and table representation type: Students were asked to move from a text containing information about pressure, visualize the situations presented in the text, and tabularize the information. The distribution of student achievements is presented in Table 2.

According to the evaluation of Table 2, there were 90 (25.9%) students able to draw an accurate image with sufficient details and information, 6 (1.7%) students answered partially true without a fault, 7 (2%) partially true with a fault, 85 (24.4%) students draws were wrong, and 160 (46%) left the question unanswered. The most frequently recurring examples of student responses were respectively partially true (S98), partially true with a false (S119), and false (S88), as shown in Figure 2.

Students answering partially true with a false, as it can be seen in the sample student answer (S119), could not draw the stones in the correct order. In other words, they interpreted the given information in the text about pressure surface area partially true and were able to draw this. Answers evaluated in the false

Table 1: Rubrics used in the classification of answers

Classification	Code	Verbal question criteria	Visual question criteria
Unanswered/meaningless	UM	Unanswered, ambiguous, or inapprehensible answers	Unfilled, ambiguous, or inapprehensible drawings/content
False	F	Students answered the question with the unscientific notions (alternative ideas)	Students, made drawings/contents in the corresponding question, reflecting unscientific notions
Partially true with a fault	PTF	Students, despite giving partially wrong/alternative answers to the question, know some basics of the topic	Students, despite reflecting unscientific notions while making drawings/contents in the corresponding question, they also made drawings reflecting the true information
Partially true without a fault	PT	Students did not give partially wrong/alternative answers to the question but answered it with basic knowledge of the topic	Students, without containing partially wrong/alternative answers to the question, made drawings/contents reflecting some basic knowledge of the topic in the corresponding question
True	T	Student answered the question with a scientific (school knowledge) level	Students in the corresponding question made drawings/contents reflecting scientific (school knowledge) level

category (S88), indicated that even if the students understood the topic correctly, they could not draw it.

According to evaluation of Table 2, moving from the text, there were 90 (4.6%) students able to draw an accurate table with the necessary information correctly presented, 6 (1.1%) students answered partially true without a fault, 9 (2,6%) partially true with a fault, 107 (30.7%) drew wrong tables, and 212 (60.9%) left the question unanswered. The most frequently recurring examples of student responses are as follows: Students' original response and a translated version are shown in Figure 3:

Students answering partially true with a fault is seen in the sample student responses (S306), and it was determined that they presented only one data out of pressure and the surface area values in the table. Answers evaluated in the false category, as seen in the sample student responses (S189), students did not address the pressure and surface area or more than one aspect of the table they drew was missing.

Transitions from visual representation type to text and table representation type: Images were given to the students about pressure. They were asked to make statements that described the images and tabularize the information given to them. The distribution of student achievements is presented in Table 3.

According to evaluation of Table 3, moving from image, there were 12 (3.4%) students able to write the explanation/text accurately with necessary information, 60 (1.7%) students answered partially true without a fault, 30 (8.6%) partially true with a fault, 113 (32.5%) made wrong statements, and 133 (38.2%) left this question unanswered. The most frequently recurring examples of student responses are as follows: Students' original responses and a translation of their response are depicted in Figure 4.

Students (e.g., S143) answering the question partially true without a fault sorted the situations in the given images correctly from small to large as expected but were not able to

Table 2: Distribution of the answers obtained from the transition of text representation type to visual and table representation types

Answers	F (%)	
	Transition: Text to image	Transition: Text to table
T	90 (25.9)	16 (4.6)
PT	6 (1.7)	4 (1.1)
PTF	7 (2)	9 (2.6)
F	85 (24.4)	107 (30.7)
U	160 (46)	212 (60.9)

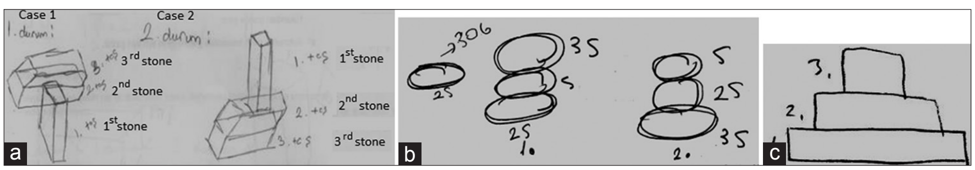
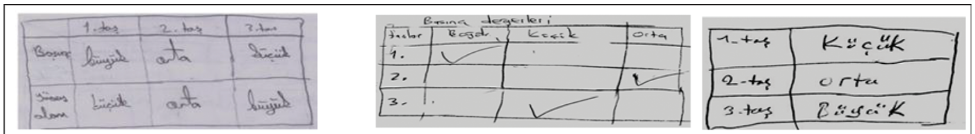


Figure 2: (a) PT - S98, (b) PTF - S119, (c) F - S88



PT - S302 | PTF - S306 | F- S189

a

	1st stone	2nd stone	3rd stone
Pressure	Big	Middle	Small
Surface area	Small	Middle	Big

b

	Pressure rating		
Stones	Big	Small	Middle
1st	X		
2nd			X
3rd		X	

c

1st stone	Small
2nd stone	Middle
3rd stone	Big

Figure 3: (a) PT - S302, (b) PTF - S306, (c) F - S189

provide the necessary explanation or vice versa. For this study, it was accepted as partially true if the students were able to correctly sort the images even if they were unable to provide an adequate explanation. Students (e.g., S133) answering questions partially true with a fault could not sort the given images correctly, but they were able to write partially true statements explaining the relations between situations. When it came to the evaluation of the answers in the wrong category, these students (e.g., S78) did not write statements explaining the given image, and instead, they wrote different textual information related to the pressure topic.

Transitions from table representation type to text and visual representation type: A table containing the pressure values of an object in certain situations was given to the students. They were asked to draw the visual status of the information given to them in the table and write a statement that described the tabular provided. The distribution of student responses is presented in Table 4.

According to evaluation of Table 4, moving from the given table, there were 77 (22.1%) students able to write the explanation/text accurately with necessary information, 4 (1.1%) students answered partially true without a fault, 15 (4.3%) partially true with a fault, 92 (26.4%) answered wrong, and 160 (46%) left the question unanswered. The most frequently recurring examples of student responses are as follows.

- PT: "The pressure and surface area are inversely proportional to each other. As ground gets smaller, pressure increases." (S15)
- PTF: "The pressure and the surface area are related. As surface area decreases, pressure increases." (S133)
- F: "Due to the difference in the surface area… As surface area decreases, pressure increases" (S5).

Considering the most frequently recurring answers, it is understood that students answering with PT and PTF could establish the relationship between pressure and surface area but could not adequately reflect it moving from the given information that was mentioned in the table. On the other hand, students answering wrong could establish the relationship between pressure and surface area but could not make the necessary description using the information given in the table.

According to the evaluation of Table 4, moving from the table, there were 6 (1.7%) students able to draw an accurate image with the expected information necessary, 13 (3.7%) students drew partially true without a fault, 14 (4%) partially true with a fault, 152 (43.7%) drew wrong images, and 163 (46.8%) did not draw any answer. The most frequently recurring examples of student responses are shown in Figure 5.

Students (e.g., S14) who answered partially true without a fault answered reflecting the information status given in the table but did not elaborate (without showing the length values) it. Students (e.g., S119) answered partially true with a fault did not do drawings reflecting the information status given in the table, but it was determined that they understood that visualization of the object was necessary. When it came to the wrong category, students (e.g., S81) did not realize the necessity of visualization of an object status moving from the table, as it can be seen in the sample answer, their drawings contained wrong information.

Table 3: Distribution of answers obtained for the transition from the visual representation type to the text and table type

Answers	F (%)	
	Transition: Image to text	Transition: Image to table
T	12 (3.4)	32 (9.2)
PT	60 (17.2)	18 (5.2)
PTF	30 (8.6)	43 (12.4)
F	113 (32.5)	93 (26.7)
U	133 (38.2)	162 (46.6)

Table 4: Distribution of student responses

Answers	F (%)	
	Transition: Table to text	Transition: Table to image
T	77 (22.1)	6 (1.7)
PT	4 (1.1)	13 (3.7)
PTF	15 (4.3)	14 (4)
F	92 (26.4)	152 (43.7)
U	160 (46)	163 (46.8)

DISCUSSIONS AND CONCLUSION

In this study, the status of students' ability to make transitions between different representation types within the frame of identified institutional relationship was examined. Moving from the findings obtained from the textbooks used during classes, the institutional relationship of representation types on pressure was limited (according to anthropological theory) with text, images, and table representation types, and it can be stated that diversities and accuracy of transitions between

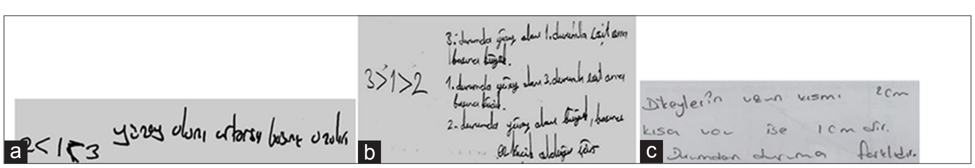


Figure 4: (a) PT-S143: If the surface area increases, the pressure decreases, (b) PTF-S133: In case 3, the surface area is equal to the 1st case, but the pressure is large. In case 1, the surface area is equal to the 3rd case, but the pressure is small. In case 2, the surface area is large; the pressure is little for small, (c) F-S78: The long side of stitches is 2 cm, and the short side is 1 cm. It is different from state to state

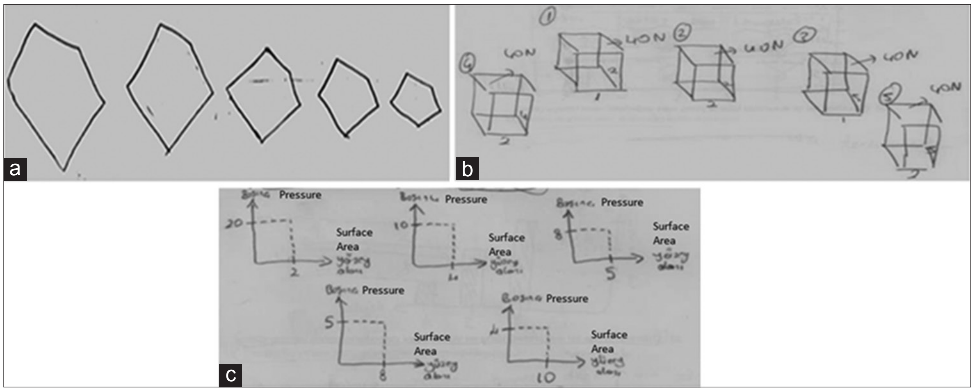


Figure 5: (a) PT - S14, (b) PTF - S119, (c) F - S81

them were not sufficient. Thus, it was understood that during the information presentation about the pressure topic to students, sufficient different types of representations were not used and the adequate explanation about how to make transitions between different types of representation was not made sufficiently. As in the curriculum which is a/the source of the textbooks, related to acquisitions from the pressure topic, besides text, and image type representations, it is asked to benefit from different various forms of representations such as graphs and tables (MEB, 2005; 2013). In the textbooks that have generally an important role in configuring the learning environment, paying attention to the presentation of knowledge with different representation types will allow the students to gain the ability to make transitions between representation types (Piez and Voxman, 1997; Keller and Hirsch, 1998; McGowan and Tall, 2001).

In spite of that, almost all of the representation types used in the examined textbooks accepted as the fundamental unit for text/verbal representation communication were composed of images. However, it has been mentioned that images are not effective or instructive and are not enabled to provide an adequate contribution to the configuration of information (Cin, 2007). Therefore, this may account for these student inabilities to make transitions between different representation types related to pressure topic. Indeed, there is supporting literature about students being affected by insufficient textbooks (Cin, 2007; Kurnaz, 2012).

In the light of the findings, related to making transitions between representation types that are used in textbooks, some of the participating students quite inadequate. Some students could not draw true/adequate images of situations given in text, even if they were simple, nor were they able to reflect them with tables. Similarly, some could not perform the transitions from table or image to other desired representation types. In fact, in this study, considering the learning situation related with performing transitions between different representation types to be associated with the conceptual configuration (Duval 1995, 2002; Piez and Voxman, 1997; Even, 1998), students' conceptual configurations were evaluated in a different perspective. Accordingly, students, despite being defined as successful after their achievement test in school, showed that they were not able to transfer the knowledge they had gained from the pressure topic to a different representation type. Similar results were stated by Kurnaz (2013) and Pektas and Kurnaz (2013), who examined the transition abilities of science teacher trainees between the representations types based on the pressure topic. In fact, the status of an expression with the different representation types related to a subject is an indicator that learning occurs in a significant way (Even, 1998; Duval, 2002; Kurnaz, 2013). This can be explained as follows by anthropological theory: Institutional relationship was reflected in the textbooks associated with pressure, but adequate ground was not formed for individual relationship in an expected way, and it may indicate that $R_I(O)$ ¹ $R(X,O)$ is not the way as it is expected again. However, as it was mentioned above, in the school environment, $R(X,O)$'s which contain the adequacy of students at different semiotic systems must be developed within the scope of $R_I(O)$, and $R_I(O) = R(X,O)$ equality must be provided.

As a result, the framework of the institutional relationship has been found not to be sufficient in the configuration of personal relationship. To improve this situation, representation types and transitions between them should be elaborated in detail in the textbooks. It is recommended that three representation types and the transitions between them should be included so that that there are open associations between them.

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APPENDICES

Appendix 1

Question 1: Kerem is rotating clockwise an irregular geometric-shaped object. The pressure of the object at the same point on the surface, and surface area values are given in the following table.

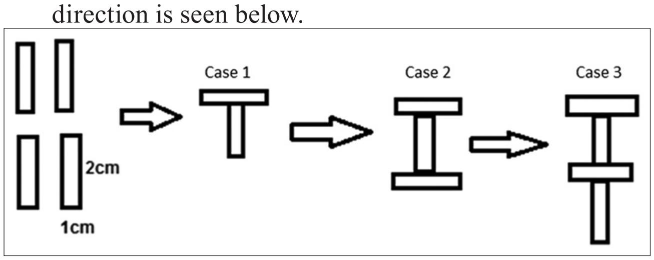
	Case 1	Case 2	Case 3	Case 4	Case 5
Pressure	20	10	8	5	4
Surface area	2	4	5	8	10

According to the table above

a. Please draw the each and every possible images of the object separately.

b. Please explain the reason/reasons for the pressure differences occurring at the same point caused by the object.

Question 2: The image which is formed placing four identical bars with 5 kg mass in the order of placing one bar under to another, one horizontal, and one vertical direction is seen below.



According to the image above

a. Please order the formed image's pressure values from small to large for each and every case and explain the reason.

b. Please draw the table that shows mass and surface area values of the bars in each case.

Question 3: While Okan is playing with a ball on a sandy ground, the ball was stuck on the branches of the tree, but despite his efforts, he could not get the ball from the tree. Suddenly, he noticed the stones at the bottom of the tree. Weights of stones were even, but shapes of stones were different. He places the stones on top of one to another but could not reach.

At first, he realized that the 1st stone was sinking more when it was placed on the ground. On this, he placed 3rd stone to the bottom on the ground, which was the last stone that was placed in the first case, and then placed the other stones in the order of, respectively, 2nd stone and 1st stone and could reach the tree. Okan understood that 3rd stone sinking less to the ground in the second case. According to this;

a. Please draw the images of first and second cases generated by Okan with stones separately.

b. Please using expressions of large, medium, and small show base-widths of stones and pressure values of them applied to the ground on a table.