Drawing Instrument and Method

Field of invention

The present invention generally relates to a drawing instrument. Particularly, it relates to a drawing instrument that facilitates the plotting of figures in geometric transformations.

Background of the Invention

The present invention provides a drawing instrument to facilitate the plotting of figures in geometric transformations. The instrument is in the form of a triangle with perforations arranged to allow multiple plotting functions to be performed with ease and precision. The drawing instrument includes a slit that defines an inner side and a curve that defines another inner side. One or more lines may be provided to facilitate the plotting. With other functional features incorporated into the drawing instrument, the present invention provides a tool that facilitates students to perform multiple plotting functions with ease and precision and provides a tool that facilitates teachers to introduce geometric transformations to students.

The teaching of geometric transformations in schools typically includes rotations, translations, reflections, and enlargement of geometric figures. Normally, students are asked to perform one or more transformations for a given geometric figure where the plotting of the figure is indicated on a paper with grid and axis lines. The plotting is performed by using a set square together with a protractor and a compass. Without the grid and axis lines on the paper, the students may find it not easy to visualize the transformation or may not be able to perform the plotting.

The present invention eliminates the use of a separate protractor and compass, which is typically required to perform the geometric transformation in schools. This is achieved by having a plurality of interlinked functional features that facilitate and guide users to plot. With the aid of a marking device such as a pencil, students may perform multiple plotting functions on a blank paper without grid or axis lines. As students progress from one plotting function to other plotting functions using the instrument of the present invention, they would be able to visualize any advanced geometric transformation with ease.

Examples of drawing instruments with perforated rulers are disclosed in DE3041724A1 (referred to as D1), DE202019003311 (referred to as D2), and DE8606551 (referred to as D3) as shown in Fig. 1, Fig. 2 and Fig. 3, respectively. It is observed that the perforations in D1, D2, and D3 do not allow certain plotting functions to be performed with ease and precision.

Items no. 1 – 23 below describe some of the plotting functions D1 could not perform under certain geometric transformations due to its limitation. The functions, however, can be performed by the drawing instrument of the present invention shown in Fig. 4 with ease and precision. The plotting functions described below are examples of questions used in teaching geometric transformation in schools.

1. Constructing an image under 90° rotation - D1 could not perform the function as hole 18 are not in line with side 4 and side 7, and the hole is not directly connected or aligned to the measurements on side 4 and side 7. The hole is inside the instrument and not at the intersection of side 4 and side 7. As hole 18 at the apex is not starting at "0", the measurement using side 4 and side 7 and marking a rotation point using hole 18 may not be accurate for drawing an image under 90° rotation. The rotation point must be in line with both sides 4 and 7. The present invention overcomes the above shortcomings by having a first hole (101) at the intersection of the first side (10) and the second side (20), which defines a "0" starting point for both measurements on the first side (10) and the second side (20).

2. Finding a centre of rotation from two images of 90° - D1 could not perform this function as hole 18 and hole 23 are not in line with side 4 and side 7, and hole 18 as the pivot point does not start at "0". The measurement to identify the centre of rotation may not be accurate. To obtain a centre of rotation, the "0" should start at the intersection of side 4 and side 7. The present invention overcomes the above shortcomings by having a first hole (101) at the intersection of the first side (10) and the second side (20) that defines a "0" starting point for both measurements on the first side (10) and the second side (20).

3. Constructing an image under 180° rotation and a three-dimensional (3D) image under 180° rotation by placing a pin - D1 could not perform the function as the third side is a curve and not straight. In other words, a straight side is not provided like the third side (30) of the present invention. According to the present invention, an image under 180° rotation is

obtained by aligning a third hole (103) at the centre of rotation. The length of any one point of the object to the centre of rotation is identified using the first eighth side (301a), and the length at the opposite ninth side (301b) is marked. The steps are repeated for other vertices in the object to obtain the full image. The above steps can also be performed for drawing 3D images under 180° rotation. The drawing instrument of the present invention is aligned with the third hole (103) at the centre of rotation, and a pin is placed on the third hole (103) to fix a point where the drawing instrument can be easily manipulated while rotating the drawing instrument.

4. Constructing an image for any angle of rotation - D1 could not perform this function, as hole 6 is not in line with side 4 and side 7 and their measurements are offset from the centre of the protractor. The present invention overcomes the shortcomings by having a fourth hole (104) at the middle of the fourth side (40) to act as a centre point between a sixth side (401a) and a seventh side (401b) and at the same time to act as a centre of rotation of protractor (50). To construct an image for any rotation angle, the fourth hole (104) will be first positioned at the centre of rotation of an object. Then, by using the sixth side (401a), measurements are taken from the vertex point on the object and angles are marked using a fifth side (50) that acts as a protractor. Next, using the seventh side (401b), the triangle is rotated, and the measurement is marked. The steps are repeated for other vertices in the object to obtain the full image. The above steps can also be performed for drawing 3D images for any angle of rotation by placing a pin on the fourth hole (104) to fix a point where the drawing instrument can be easily manipulated while rotating the drawing instrument.

5. Finding a centre of rotation from two images under 90° rotation - D1 could not perform the function as it requires a 45° point. The 45° value does not start from side 4 and side 7, and no specific hole is provided to facilitate the function. In addition, hole 6 connected to the protractor is not in line with side 4 and side 7 and their measurements are offset from the centre of rotation of the protractor. The present invention overcomes the shortcomings by having a fourth hole (104) at the middle of the fourth side (40) to act as a centre point between a sixth side (401a) and a seventh side (401b), and at the same time to act as a centre of protractor wherein the fourth hole (104) and the fourth side (40) work together

with a fifth hole (105a) and a sixth hole (105b) for finding the centre of rotation from two images under 90° rotation, as shown in Figure 7.

6. Constructing circles or radius when specific measurement values are given - The calculations shown in Fig. 1b and Fig. 1c indicate that the holes in zone A and zone B in the drawing instrument of D1 are not designed with measurements readings. The present invention provides a first line (201) with specific measurements and specific intervals indicated for constructing circles or radius with specific measurement values as shown in Fig 4a. and Figs. 4b (i),(ii) and (iii).

7. Finding a centre of rotation from two images of 180° rotation - D1 could not perform the function as the third side is not straight. In other words, a straight side is not provided like the third side (30) of the present invention. To overcome the above limitation, the present invention provides the third hole (103) on the third side (30) with an eighth side (301a) and a ninth side (301b) to facilitate finding the centre of rotation for 180° based on the two images.

8. Finding the centre of rotation from two images from an unspecified angle of rotation - D1 could not perform the function as no straight side is provided like third side (30) with eighth side (301a) and ninth side (301b) that works with a second line (202) to align the perpendicular line and to mark the perpendicular line using the first hole (101), fourth hole (104) and third hole (103) as reference points to draw a straight line and mark the centre of rotation from the two images. The second straight line is drawn from different vertex points. The crossing of these two straight lines indicates the centre of rotation for the two images.

9. Constructing images from the reflection axis and drawing 3D reflection images - D1 could not perform the functions as no straight side is provided like the third side (30) with an eighth side (301a) and a ninth side (301b) that works with the second line (202). To overcome the above limitations, the present invention provides the third side (30) with the eighth side (301a) and ninth side (301b), and the second line (202) to facilitate drawing the image by placing the third side (30) on one of the vertex points of the object. The second line (202) on the reflection axis is slide along the line from one vertex to another. The length between objects vertices to the reflection axis is identified, and the length is

marked on the eighth side (301a) or the ninth side (301b). The same steps are followed for drawing a 3D reflection image, as shown in Fig. 17a, 17b, and 17c.

10. Finding a reflection axis from two images - D1 could not perform the function as no straight side is provided, like the third side (30) with an eighth side (301a) and a ninth side (301b) that works along with the second line (202). According to the present invention, the reflection axis is obtained by identifying the same vertex point in both images and placing the third side (30) according to the length. When the same length on the eighth side (301a) and ninth side (302b) is identified, points are marked at the third hole (103), fourth hole (104), second hole (102) and first hole (101), which indicate the bisector line and the reflection axis. A line is drawn based on the marked points.

11. Finding a centre of circles of various diameters - D1 could not perform the function as the feature of the protractor is at 90° angle and not at 180° angle. According to the present invention, the normal line is obtained by aligning the fourth hole (104) at any point in the circumference of a circle. The drawing instrument is turned until the same value on both sides of the protractor (50) is identified, and points are marked at the third hole (103), second hole (102) and first hole (101), indicating the normal line. A first line is drawn based on the marked points. The same steps are repeated for other points in the circle to obtain the second line. The crossing of the first and second lines represents the centre of the circle.

12. Drawing a 3D rotation of 90° by placing a pin - D1 could not perform the function as hole 18 provided in the instrument are not in line with side 4 and side 7, and the hole is not directly connected or aligned to the measurements on side 4 and side 7. The hole is inside the ruler and not at the intersection of side 4 and side 7. As hole 18 at the apex point is not starting at "0", the measurement using side 4 and side 7 and marking a rotation point is inaccurate for drawing an image under 90° rotation. The present invention overcomes the above shortcomings by providing a first hole (101) at the intersection of the first side (10) and the second side (20) that defines a "0" starting point. According to the present invention, a 3D image is obtained by aligning the first hole (101) at the centre of rotation and placing a pin to fix the point. The object's length from one point of the vertices to the centre of rotation is identified on the first side (10) or second side (20), and the said length

is marked on the second side (20) or first side (10), respectively. The steps are repeated for other vertices in the object to obtain a fully drawn 3D image as shown in Fig.14b and Fig 15a,15b and 15c

13. Constructing a tangential line from a given point on a circle - D1 could not perform the function as the protractor is limited to 90° angular measurement. To construct a tangential line, a 180° protractor is required to mark the same angle at both sides of the protractor. According to the present invention, a tangential line is obtained by aligning the fourth hole (104) at a given point on the circle. The drawing instrument is turned until the same angular value on both sides of the 180 ° protractor (50) is identified and marked. If the centre of a circle is given, the second line (202) will overlap the marked point. A line is drawn along the sixth side (401a) or the seventh side (401b) on the fourth side (40) to indicate the tangential line.

14. Constructing a triangle with a given length - D1 could not perform the function as calculations in Fig.1a and Fig.1b indicate that the holes in zone A and zone B are not designed with specific measurement readings that can function as the first line (201) of the present invention. The present invention provides a first line (201) with specific measurements with specific intervals indicated to construct circles or radius with specific measurement values, as shown in Fig. 4a and Fig. 4b and a triangle shown in Fig. 10. Referring to Figs. 10a,10b and 10c, the width of 6.1 cm is drawn on a straight line corresponding to KL length. 5.2 cm length is set and a first arc is drawn from point L. 2.8 cm length is set and a second arc is drawn from point K. The second arc that crosses the first arc indicates a third vertex of the triangle.

15. Enlargement with a positive scale factor and fraction scale factor, and 3D enlargement drawing - D1 could not perform the function as hole 18 and hole 23 provided in the instrument are not in line with side 4 and side 7, and the holes are not directly connected or aligned to the measurements on side 4 and side 7. The holes are provided inside the ruler and not at the intersection of side 4 and side 7. As hole 18 at an apex is not starting at "0", the measurement using side 4 and side 7 and marking an enlargement rotation point may not be accurate for drawing an enlarged image under a positive scale factor. The centre of the enlargement point must be in line with both sides 4 and 7. The present invention

overcomes the above shortcomings by having a first hole (101) at the intersection of the first side (10) and the second side (20) that defines a "0" starting point. According to the present invention, an enlarged image is drawn by aligning the first side (10) at one vertex and placing the first hole (101) at the centre of enlargement. The length is identified and multiplied by the scale factor. If the scale factor is 2, the length is multiplied by 2. The calculated value is then marked on the first side (10) or second side (20) to indicate the enlargement point. The steps are repeated for other vertex points in the object. The steps are followed for drawing 3D positive enlargement images by aligning the first hole (101) at the centre of enlargement and placing a pin to fix a point so that the drawing instrument can be easily manipulated as shown in Fig 11b and Fig 12a.

16. Image enlargement with a negative scale factor and 3D enlargement drawing - D1 could not perform the function as there is no straight edge like the third side (30) as provided in the present invention. According to the present invention, an image enlargement is drawn by placing the third side (30) at one vertex of the object and placing the third hole (103) at the centre of enlargement. The length is identified and multiplied by the negative scale factor. If the scale factor is -2, the length is multiplied by 2. The calculated value is then marked at the opposing eighth side (301a) or ninth side (301b) to indicate the enlargement point. The steps above are repeated for other vertex points in the object. The same steps are followed for drawing 3D negative enlargement images by aligning the third hole (103) at the centre of enlargement and placing a pin to fix the point so that the drawing instrument can be manipulated while marking the points as shown in Figure 13b.

17. Inscribe a circle in a triangle - D1 could not perform the function as calculations in Figs. 1a and 1b show that the holes in zone A and zone B, as provided in the drawing instrument of D1, are not designed with measurement readings. At the same time, it could not perform the function as the feature of the protractor is at 90° angle and not at 180° angle. According to the present invention, the centre of the circle inscribed in a triangle is the centre of the triangle, a point where the angle bisectors of the triangle meet. This can be obtained by aligning the fourth hole (104) at the vertex point of the triangle. The present instrument is turned until the user identifies the same value on both opposite sides of the protractor. When the user observes the same value, then the user marks at the third hole (103), second hole (102) and first hole (101), which indicates the bisector angle of two sides. A line is drawn and the steps are repeated for another vertex point of the triangle. The crossing of

these two lines represents the centre of the circle and the first line (201) provides specific measurements and intervals to construct circles or radius values as shown in Fig 4a and Fig 4b. The circle's centre can be obtained from the intersection of the lines drawn from the two bisector angles between two edges of the triangle, wherein a distance from the centre to one side of the triangle defines a radius to draw a circle that touches the sides of the triangle.

18. Circumscribe a circle on a triangle. D1 could not perform the function as calculations shown in Figs. 1a and 1b show that the holes in zone A and zone B, as provided in the drawing instrument of D1, are not designed with measurement readings. At the same time, it could not perform the function as there is no straight edge like the third side (30). According to the present invention, the centre of the circumscribed circle is the centre of the triangle, a point where the perpendicular bisectors of the sides meet. This can be obtained by placing the third side (30) on any one side of the triangle. When the same value is identified on both opposite sides of the third side (30) on one side of the triangle, the length is marked at the third hole (103), fourth hole (104), second hole (102) and first hole (101) to indicate the bisector line. The same steps are observed for the other side of the triangle and place the third side (30) according to length, respectively. Another line is drawn and the crossing of these two lines is the centre of the circle. The first line (201) provides specific measurements and intervals to construct circles or radius values as shown in Fig. 4a and Fig. 4b. The circle's centre can be obtained from the intersection of the lines drawn from the two bisector lines between two sides of the triangle wherein a distance from the centre to a vertex of triangle defines a radius to draw a circle that touches the circle vertices of the triangle.

19. Drawing parallel lines - D1 could not perform the function as no straight side is provided like the third side (30) with the eighth side (301a) and ninth side (301b) that works with the second line (202). To overcome the above limitation, the present invention provides the third side (30) and the second line (202) to draw the parallel lines by placing the second line (202) on the main line. While the second line (202) is on the main line, the user needs to identify the length of the parallel line to be drawn by marking the same corresponding length on both eighth and ninth sides (301a, 301b). The same steps are followed for other points on the main line. The marked points indicate the parallel line, and the parallel line is drawn.

20. Drawing a main line from two parallel lines - D1 could not perform the function as no straight side is provided like third side (30) with eighth side (301a) and ninth side (301b) that works along with second line (202). To overcome the above limitation, the present invention provides the third side (30) and second line (202) to facilitate drawing the main line by placing the third side (30) on the two parallel lines and identify the same value on both eighth side (301a) and ninth side (301b). When the same value of length on both sides 301a and 301b are identified, points are marked at the third hole (103), fourth hole (104), second hole (102) and first hole (101) to indicate the main line between the two parallel lines. A line is drawn based on the marked points.

21. Translation of images in z-axis - D1 could not perform this function with precision, as hole 6 is not in line with side 4 and side 7 and their measurements are offset from the centre of rotation of the protractor. The above shortcomings are overcome by having a fourth hole (104) at the middle of the fourth side (40) that acts as a centre point between the sixth and seventh sides (401a, 401b) and acts as a centre of rotation of the protractor (50). To draw the translation in the z-axis, the user must determine the angle of the z-axis from the origin point by placing the fourth hole (104) at the centre point and the fourth side (40) along the x-axis. The angle is observed from the protractor (angle example: 60°) and later applied for all the vertex points on the object. Then, the fourth hole (104) will be positioned at the vertex point of an object, with the fourth side (40) parallel to the x-axis. The user marks 60° on the protractor, and the instrument is turned until the pencil touches the fourth side (40) and marks the length on the fourth side (40) as mentioned in the question. The steps above are repeated for another vertex point in the object. Image is drawn based on the marked points as shown in Fig.6

22. Drawing 3D figures for any angle of rotation - D1 could not perform this function, as hole 6 is not in line with side 4 and side 7 and their measurements are offset from the centre of rotation of the protractor. The above shortcomings are overcome by having a fourth hole (104) at the middle of 40 that acts as a centre point between the sixth and seventh sides (401a) and (401b) and acts as a centre of rotation of protractor wherein to construct a 3D figure, the fourth hole (104) will be first positioned at the centre of rotation and measurement is observed on the sixth side (401a) or seventh side (401b) on one end of the

vertex point. Then, the angle is marked using the protractor. Next, the fourth side (40) is rotated until it reaches the marked angle. Using the sixth side (401a) or seventh side (401b), measurement is marked from the vertex point of the object and a straight line is drawn. The same steps are repeated for another end of the line until a full geometric image is produced.

23. Constructing refraction of waves (trapezium) - D1 could not perform this function, as hole 6 is not in line with side 4 and side 7 and their measurements are offset from the centre of rotation of the protractor. The above shortcomings are overcome by having a second line (202) as a perpendicular line, a fourth hole (104) at the middle of 40 that acts as a centre point between the sixth and seventh sides (401a, 401b) and acts as a centre of rotation of protractor. To construct refraction of waves, the second line (202) will be on any wavefronts and the fourth hole (104) will be at the border of the deep and shallow region. Users draw a line along the fourth side (40), representing the normal line and direction of propagation. Since the wavefronts move from a less dense to a denser region, wave propagation moves towards the normal line. Next, the fourth hole (104) and second line (202) are positioned on the shallow region's wavefront line and adjusted until the fourth side (40) touches the first wavefront in the deep region. The wavefronts are drawn along the fourth side (40), which indicate the wavefronts in the denser region.

With regard to the drawing instrument of D2 as shown in Fig. 2, the slanting sides A1 and A2 of the triangle are provided with angular measurements wherein the markings correspond to the value of the protractor. The holes at the bottom side of the triangle are provided with specific positions. The holes at one side A4 are positioned at 0.5cm, 1.5cm, 2.5cm, 3.5cm, 4.5cm, and 5.5cm. The holes at the other side A3 are positioned at 0cm, 1cm, 2cm, 3cm, 4cm, 5cm and 6cm. A circle can only be drawn from one fixed point at 0cm as an initial reference point. With these features, circles may not be drawn with an accurate measurement. For example, if a question requires a circle with a radius of 4.3 cm, a circle with a 4.5 radius can only be drawn instead of an accurate 4.3 cm as the triangle has the precision of 0.5cm. The shortcomings are overcome by having a first line (201) in the present invention. A slit as provided in the present invention is also not disclosed to facilitate the drawing of images.

The fifth hole (105a) and sixth hole (105b), and a slit as provided in the present are not disclosed in D3 shown in Fig. 3. In the present invention, the slit is provided with a fourth hole

(104) in line with the second line (202), first hole (101), second hole (102) and third hole (103), wherein the first hole (101) and third hole (103) are placed outside the triangle and in line with the corresponding sides. The first hole (101) is placed at the intersection of the first side (10) and the second side (20), whereas the third hole (103) is in line with the third side (30). The positions of the holes allow the marking in respect of the measurements on the sides 10, 20, 30 to always start at 0 and in line. The holes at the bottom side of D3 are without any specific markings and intervals that would not function as the holes provided in the first line (201) of the present invention. It is observed that at least five holes are provided within 1cm on D3. This provides a series of holes spaced with a 0.2cm interval, and the hole starts at 0.6cm from the centre. With these features, circles may not be drawn with an accurate measurement. For example, if a question requires a circle with a radius of 3.1cm to be drawn, students may only draw a circle with a radius of 3.0cm or 3.2cm instead of 3.1cm. The shortcomings are overcome by having the first line (201) in the present invention.

The drawing instruments of D2 and D3 could not construct an image under a 3D 180° rotation by placing a pin as there is no third hole (103) as provided in the present invention. According to the present invention, an image under a 3D 180° rotation is obtained by aligning the third hole (103) at the centre of rotation and placing a pin to fix the point. The length of any one point of the object is identified and marked at the opposite eighth side (301a) or ninth side (301b). The steps are repeated for other vertices in the object to obtain the full image. The above steps can also be performed for drawing 3D images for 180° rotation wherein for this function, the triangle is aligned with the third hole (103) at the centre of the rotation and a pin is placed to fix a point so that the triangle can be easily manipulated.

Students may not be able to find the centre of rotation from two images under 90° rotation easily with D2 and D3 as there are no specific holes for 45° points on both sides to guide and facilitate the students to mark the 45° points. The present invention overcomes the shortcomings by having a fifth hole (105a) and a sixth side (105b), and a fourth hole (104) at the middle of the fourth side (40) to act as a centre point between the sides 401a and 401b, and to act as a centre of protractor wherein the fourth hole (104) and the fourth side (40) work together with fifth hole (105a) and sixth hole (105b) for finding the centre of rotation from two images under 90° rotation, as shown in Figure 7. The measurement to identify the centre of rotation may not be accurate. To obtain a centre of rotation, the "0" should start at the intersection between the slanting sides. The present invention overcomes the above

shortcomings by having a first hole (101) at the intersection of the first side (10) and the second side (20) that defines the apex point that starts at "0".

The drawing instruments of D2 and D3 could not draw a 3D rotation of 90° by placing a pin. The units and lines on the slanting sides A1 and A2 of D2 are angle lines with angle values. The lines correspond to the protractor value. The units used on the slanting sides B1 and B2 of D3 are different, and the measurements therein do not correlate to one another. Referring to Fig. 3, the slanting side B1 of D3 uses pie (π) unit while B2 uses inches unit.

The drawing instruments of D2 and D3 could not construct a triangle with a given length that requires an answer with a precision of 0.1 cm. The present invention provides the first line (201) with specific measurements and intervals to construct circles or radius. The construction of a triangle is shown in Figs. 9(i),(ii) and (iii). Following the measurement given in a question, the width of 6.1 cm is drawn on a straight line corresponding to KL length. 5.2 cm length is set and drawn a first arc from point L. 2.8 cm length is set and a second arc is drawn from point K and the second arc will cross the first arc to indicate a third vertex of the triangle. If students are required to draw the triangle as above measurement, D2 could not draw as the instrument is limited to a precision of 0.5 cm. It only can draw 0.5cm, 1.0cm, 1.5 cm, 2.0cm and so on. D3 has a precision of 0.2cm. It is observed that the interval between one hole to another is 0.2cm. There is no numbering to each hole and the first hole starts from 0.6cm. D3 could not draw circles or triangles with accurate measurements. It can only draw 0.2cm, 0.4cm, 0.6cm, and so on.

The drawing instruments of D2 and D3 could not perform an image enlargement with positive scale factor and fraction scale factor, and a 3D image enlargement drawing as there is no first hole (101) as provided. According to the present invention, an image enlargement is drawn by placing the first side (10) or second side (20) at one vertex point in the object and placing the first hole (101) at the centre of enlargement. The length from the first hole (101) to the vertex is identified and multiplied by the scale factor. If the scale factor is 2, the length is multiplied by 2. The calculated value is then marked at the first side (10) or the second side (20) to indicate the enlargement point. The steps are repeated for other vertex points in the object. At the same time, the same steps are followed for drawing 3D positive enlargement images. It is obtained by aligning the first hole (101) at the centre of enlargement and placing a pin to fix the point

so that the triangle can be easily manipulated while marking the points and drawing the 3D image.

The drawing instruments of D2 and D3 could not perform an image enlargement with a negative scale factor and a 3D image enlargement drawing as there is no third hole (103) as provided in the present invention. According to the present invention, an image enlargement is drawn by placing the third side (30) at one vertex and placing the third hole (103) at the centre of enlargement. The length from the third hole (103) to the vertex is identified and multiplied by the negative scale factor. If the scale factor is -2, the length is multiplied by 2. The calculated value is marked at the opposing eighth side (301a) or the ninth side (301b) to indicate the enlargement point. The steps above are repeated for other vertex points in the object. The same steps are followed for drawing an enlarged 3D image with a negative scale factor. A 3D image is obtained by aligning the third hole (103) at the centre of enlargement and placing a pin in a fixed position to manipulate the triangle for drawing the 3D image quickly.

It is to be noted that teaching students to draw images under rotation is a challenge for teachers in primary schools. For example, in teaching 90 °rotation, students may find the steps for drawing the required images difficult as they will need to have additional instruments such as protractors and compasses and learn how to use the same. Without adequate instruments, they may not be able to perform the function taught by their teachers.

Teachers in primary schools may find that explaining centre of rotations on images is not a straightforward task as it requires students to visualize the rotation. The current method relies solely on a Cartesian plane and grid lines whereby teachers may need to explain the possible positions for the centre of rotation, e.g. whether they are inside, at the left or right side, or any position around the images.

Figs. 16c (i) and (ii) show a conventional way of finding a centre of rotation that involves a Cartesian plane and grid lines that require compass and bisector lines where students are taught to count the boxes within the grid lines to identify the centre of rotation. While this method is valid, students may become too dependent on grid lines to solve other questions.

For instance, students may have to visualize the movement of figures when the figures move along a circular arc or in orbit around the centre of rotation. The area for centre of rotation varies with different types of questions. Students have to pre-imagine a triangle ABC as an

object that has been rotated to create an image triangle A'B'C'. This visualization process would be a hurdle for teachers as students in primary schools have different ways to perceive geometric transformation and have different levels of spatial thinking.

In teaching geometric transformation, teachers would need to ensure that students grasp the basic understanding. This task is time-consuming and may require many hours in the classroom. Alternatively, computer software may be used to allow students to modify the objects on the computer screen. This method is only applicable in the presence of the computer. While the said method is helpful, it does not explain the geometric transformation outside the computer lab. The present invention provides a new perspective in visualizing geometric transformation and a new method that aims at student's five senses to better understand geometric transformation.

As a single tool or instrument, the present invention can be used anytime and anywhere to learn and teach geometric transformation and be affordable to schools and parents. Students in third world countries and those who do not have access to computers will find the present invention beneficial and cost-saving. As the present invention allows a simplified method, the time spent to teach the subject can be decreased, and the teachers can use the extra time to do more tasks to develop students' thinking skills to a higher level.

Accordingly, to allow students to grasp a fundamental understanding of centre of rotation, the present invention provides a fifth hole (105a) and a sixth hole (105b) to strengthen their visualization and spatial thinking. Together with other interlinked features on the present invention, these features allow students to visualize and identify the object's position and image from the questions with ease. The visualizing and identifying processes are achieved by imagining a circular arc in orbit and placing the first hole (101) at the area of angular rotation. At the same time, students can also identify the same vertex point on both object and image by placing the fourth hole (104) on point A in the object and rotating the fourth side (40) to another point A' in the image. 45 ° point from point A' is then identified and marked in the fifth hole (105a) using a pencil. Any straight edge on the triangle can be used to draw a first line from point A to the marked point in the fifth hole (105a). The same step is repeated for other vertex points in the image. The fourth hole (104) is placed on Point A' of the image, and the fourth side (40) is rotated to other points A of the object. 45-degree point from point A is identified and marked in the sixth hole (105b) using a pencil. Any straight edge on the triangle is used to draw a second line from point A’ to the marked point in the sixth hole (105b). The crossing of

the first and second lines are the centre of rotation for 90° rotation. This method can be used on papers with grid lines and blank papers without grid lines.

The teaching of geometric transformations using the present invention allows students to easily visualize the turning point or rotation of the geometric figures. With the method according to the present invention, the teachers can easily monitor students' progress whether they have understood the given questions before proceeding with more challenging questions that require higher thinking skills.

In view of the shortcomings of the existing drawing instruments, it is the object of the present invention to provide a drawing instrument with improved and functional features to overcome the shortcomings that allow the particular plotting functions to be performed with ease and precision. The present invention aims to provide a single tool or instrument that allows students to visualize geometric transformation easily without any additional drawing instruments such as compasses and protractors. Another object of the present invention is to provide a single tool that allows teachers to teach geometric transformation with ease and precision without additional drawing instruments such as compasses and protractors.

Summary of the Invention

The present invention provides an improved drawing instrument with perforations, lines and sides to facilitate the plotting of figures for geometric transformations. The drawing instrument of the present invention is in the form of a set square or triangle. The drawing instrument comprises perforations to facilitate users to perform multiple plotting functions with ease and precision. The drawing instrument includes a slit that defines an inner side and a curve that defines another inner side. The drawing instrument further includes one or more lines to facilitate the plotting functions. The combination of the perforations, sides, and lines in the drawing instrument provides a single tool that allows multiple plotting functions to be performed with ease and precision.

According to an embodiment of the present invention, the drawing instrument comprises perforations and sides to facilitate the plotting of figures for geometric transformations, wherein the sides include a first side (10), a second side (20) and a third side (30) forming a triangle, a slit with a fourth side (40) and a fifth side (50); and the perforations include a first hole (101), a second hole (102), a third hole (103), a fourth hole (104), a fifth hole (105a) and a sixth hole (105b) characterized in that the first, second, third and fourth holes (101,102,103,104) are in line; wherein the fourth hole (104) is a centre point between a sixth side (401a) and a seventh side (401b) and a centre point of the fifth side (50) and interlinked with the fifth and sixth holes (105a, 105b) to indicate 45° point; wherein the first hole (101) is at an intersection of the first and second sides (10,20), and the third hole (103) is in line with the third side (30) and is a centre point between an eighth side (301a) and a ninth side (301b).

According to a further embodiment of the present invention, the first line (201) as shown in Fig. 4a and Figs. 4b (i), (ii) and (iii) comprises a series of holes arranged at specific intervals. The intervals may include a main scale and an internal scale. The scales are configured and spaced accordingly at different regions, with constant scale fractions. The first line (201) scales with 0.1cm accuracy are provided by locating the optimal perforated alignment between the main and internal scales.

Below the scale of 0.0 cm in the first line (201) is the initial point of the main scale where the holes are constructed with a specific value of 0.5cm with each other. These holes act as the main scale as they are spaced with each at a constant fraction value.

Meanwhile, the internal scale is located at the top marked scale of '0.0'cm, and it starts with 0.2 cm, 0.4cm, 0.6cm and 0.8 cm. The top internal scale is aligned by 0.2 cm intervals and has only four holes in total. The bottom internal scale, located right below the '0.0'cm mark, consists of one hole marked as a 0.3cm value.

For any measurement ranging from 0.2cm until 8.8cm, it only requires users to use a pair of marking tools and placing them in the holes of the first line (201). The scales or readings of the first line (201) are found by locating the optimal perforated alignment between the main and internal scales.

The present invention also provides a method involving the use of the drawing instrument for drawing certain geometric transformations.

An embodiment of the method comprises a method for constructing a 3D image under 180° rotation with a pin using the drawing instrument comprising the steps of aligning the third hole (103) at a centre of rotation of an object; identifying a length of one or more vertices of the object from the centre of rotation using the eighth side (301a); placing a pin on the third hole (103) to manipulate a rotation of the drawing instrument; and marking the identified length at the ninth side (301b) to obtain the 3D image.

Another embodiment of the method comprises a method for finding a centre of rotation from two images under 90° rotation comprising the steps of placing the first hole (101) of the drawing instrument at an area; placing the fourth hole (104) on a vertex in the first image and aligning a corresponding vertex in the second image with the fourth side (40); placing a first mark on the fifth hole (105a) and connecting the first image vertex point and the first mark to indicate a first line; placing the fourth hole (104) on the corresponding vertex in the second image and aligning the vertex in the first image with the fourth side (40); and placing a second mark on the sixth hole (105b) and connecting the second image vertex point and the second mark to indicate a second line wherein a crossing of the first and second lines is the centre of rotation.

Another embodiment of the method comprises a method for finding a centre of rotation from two images under 90° rotation using the drawing instrument comprising the steps of identifying a vertex point and the corresponding vertex point in the first image and a second image using

the first side (10) and the second side (20) whereby the lengths from the first hole (101) to the first side (10) and the second side (20) should correspond to each other or same; and placing a mark on the first hole (101) to indicate the centre of rotation for 90° rotation.

Another embodiment of the method comprises a method for constructing circles or radius with a radius of the circle involves a 0.1 cm precision using the drawing instrument comprising the step of marking the one or more points for the radius using the first line (201)

Another embodiment of the method comprises a method for drawing a 3D image under rotation of 90° using a pin using the drawing instrument comprising the steps of: aligning the first hole (101) at a centre of rotation of an object; placing the pin on the first hole (101) to manipulate a rotation of the drawing instrument; identifying one or more lengths of the object from one or more vertices to the centre of rotation on the first side (10) or second side (20); and marking the length on the second side (20) or first side (10).

Another embodiment of the method comprises a method for drawing a triangle with one or more lengths of the triangle involves precision of 0.1 cm using the drawing instrument comprising the step of marking one or more points for drawing radius corresponding to the length using the first line (201).

Another embodiment of the method comprises a method for drawing a 3D enlargement with negative scale factor using the drawing instrument comprising the steps of: aligning the third side (30) at one vertex and placing the third hole (103) at a centre of enlargement of an object; identifying one or more lengths of the object from one or more vertices to the centre of enlargement; multiplying the lengths by a negative scale factor to obtain a value; marking the value on the eighth side (301a) or ninth side (301b) to indicate points for the enlargement; and placing a pin on the third hole (103) to manipulate a rotation of the drawing instrument while marking the points.

Another embodiment of the method comprises a method for drawing a 3D enlargement of an object with a positive scale factor using the drawing instrument comprising steps of: aligning the first side (10) at one vertex of the object and placing the first hole (101) at a centre of enlargement of the object; identifying one or more lengths of the object from one or more

vertices to the centre of enlargement; multiplying the length by the positive scale factor to obtain a value; marking the value on the first side (10) or second side (20) to indicate one or more points for the enlargement; and placing a pin on the first hole (101) to manipulate a rotation of the drawing instrument while marking the points.

5

The present invention also provides the use of the drawing instrument for drawing certain geometric transformations with steps as mentioned above.

Brief Description of Drawings

Fig. 1 shows a drawing instrument disclosed in a prior art document;

Fig. 1a shows an enlarged view of an illustration made on Fig. 1;

Figs. 1b and 1c show calculations based on Fig. 1a;

Fig. 2 shows a drawing instrument disclosed in another prior art document;

Fig. 3 shows a drawing instrument disclosed in yet another prior art document;

Fig. 4 shows a drawing instrument of the present invention according to an embodiment;

Fig. 4a shows an enlarged view of a portion of a first line shown in Fig. 4 with a sequence of holes;

Fig.4b(i), (ii) and (iii) show a sequence of holes and measurements on the first line shown in Fig. 4;

Figs. 5a shows an example of a question for drawing an image under translation;

Figs. 5b and 5c show the steps for translating the object in the x-axis and y-axis using the drawing instrument of the present invention based in Fig. 5a;

Fig. 6a shows an example of a question for drawing an image under translation;

Figs. 6b, 6c, 6d, and 6e show the steps for translating the object in the question using the drawing instrument of the present invention based on Fig. 6a;

Fig. 7a shows an example of a question for finding a centre of rotation for 90° rotation of two images;

Figs. 7b, 7c, 7d and 7e show the steps for finding a centre of rotation for 90° angle using the drawing instrument of the present invention based in Fig. 7a;

Fig. 8a shows another example of a question for finding a centre of rotation for 90° rotation of an object and its corresponding image;

Figs. 8b and 8c show the steps for finding a centre of rotation for 90° rotation of an object and its corresponding image based on Fig. 8a;

Figs. 9(i), (ii) and (iii) show a construction of a triangle with specific lengths;

Figs. 10a and 10b show drawings of wavefronts for constructive and destructive interference with different colours;

Fig. 11a shows an example of a question for drawing an image enlargement with a positive scale factor and fraction scale factor;

Figs. 11b and 11c show the steps for drawing the image enlargement in Fig. 11a;

Fig. 12a, 12b and 12c shows examples of 3D image enlargement;

Fig. 13a shows an example of a question for an image enlargement with a negative scale factor;

Figs. 13b and 13c show the steps drawing an image enlargement with a negative scale factor;

Fig. 13d, 13e and 13f show examples of 3D image enlargement;

Fig. 14a shows an example of a question for constructing an image for 90° rotation;

Figs 14b and 14c show the steps for the image construction in Fig. 14a;

Figs. 15a, 15b and 15c show examples of 3D image rotation;

Figs. 15d, 15e and 15f show examples of 3D applications under 180° rotation;

Figs. 16a and 16b show the conventional way of drawing a reflection image based on the reflection axis;

Figs. 16c (i) and (ii) show a conventional way of finding a centre of rotation; and

Fig. 17a, 17b, and 17c show examples of 3D reflection images.

Detailed Description of the Invention

The conventional teaching of translation of an object for primary students in the current education system is using a Cartesian plane or grid lines. Grid lines provide the length and units to move an object to the right or left direction and up or down. Accordingly, students are taught to count the boxes within the line graph to move the figure in the given direction. Without the Cartesian plane or grid lines, the student may not be able to visualize the translation of the object and may find it difficult to plot the image.

With the drawing instrument of the present invention, the student may use the first side (10) and first hole (101) to do a translation of the object with ease. The student may position the first side (10) parallel to the x-axis to measure the required distance, use the first hole (101) as a reference point, and then use the second side (20) to mark the vertical translation or displace it from its initial points. This method can be performed on blank paper without the need for grid lines.

To displace the object in the z-axis, the angle of the z-axis is first determined using the protractor. The fourth hole (104) is placed on any vertex point of the object, and the fourth side (40) is placed parallel to the x-axis in the image. The pencil is placed on the z-axis angle on the protractor. The instrument is turned until the pencil touches the fourth side (40) and marks the same length at the side of the fourth side (40). The steps are repeated for other vertices. This unique method which involves the z-axis gives a new dimension to learning translation.

Figs. 1, 2 and 3 show the existing drawing instruments disclosed in DE3041724A1 (referred to as D1), DE202019003311 (referred to as D2), and DE8606551 (referred to as D3), respectively.

Fig. 1a shows an enlarged view of the illustration made on Fig. 1 and calculations based on Fig. 1a are shown in Figs. 1b and 1c. It is observed that there is a limitation if a radius of 0.4cm is to be obtained. If points are marked at 3.0 cm and 3.4 cm to draw a circle with a radius of 0.4cm, the actual radius drawn is 2.04 cm.

- Calculation for © distance on Fig. 1b

$C^2 = A^2 + B^2$

$C = \sqrt{A^2 + B^2}$

$$=\sqrt{(0.4\ cm)^2 + (2.0\ cm)^2}$$

$$= \sqrt{(0.16\ cm) \quad + (4.0\ cm)}$$

$$= \sqrt{4.16}$$

$$= 2.04 \text{ cm}$$

- The © distance is 2.04 cm

Based on the diagram in Fig. 1b, the calculation shows that the length (A) and length (B) do not provide specific measurements.

In another example shown in Fig. 1c, points are marked at 3.0 cm and 3.9 cm and the actual radius is 4.38.

- Calculation for © distance

$C^2 = A^2 + B^2$

$C = \sqrt{A^2 + B^2}$

$$=\sqrt{(3.9\ cm)^2 + (2.0\ cm)^2}$$

$$= \sqrt{(15.21\ cm) \quad + (4.0\ cm)}$$

$$= \sqrt{19.21}$$

$$= 4.38 \text{ cm}$$

- The © distance is 4.38 cm

The calculation shows that the length (A) and length (B) in Fig. 1c do not provide specific measurements. The above calculations indicate that the holes are not designed with the actual reading.

Fig. 4 shows a drawing instrument of the present invention according to an embodiment. The drawing instrument comprises perforations and sides to facilitate the plotting of figures for geometric transformations. The first side (10), the second side (20) and the third side (30) forms a triangle. A slit with a fourth side (40) is provided, wherein the fourth side (40) defines a straight inner side. The fifth side (50) is a curved inner side that acts as a protractor. A ruler

may be provided at the middle of the triangle to bridge the fourth side (40) and the fifth side (50).

The first hole (101), second hole (102), third hole (103), fourth hole (104) are in line. The fourth hole (104) is at the middle of the fourth side (40) to act as a centre point between a sixth side (401a) and a seventh side (401b) and as a centre point of the fifth side (50) and interlinked with the fifth and sixth holes (105a, 105b) to indicate 45° point for marking and measurement. The fifth side (50) is a curve to act as a protractor with angular measurements corresponding with the fourth hole (104). The second line (202) in line with the first, second, third and fourth holes (101,102,103,104).

The first hole (101) is at an intersection of the first and second sides (10,20). A protruding portion at the triangle's apex is provided to place the first hole (101). This protruding portion allows the first hole (101) to be in line with the first and second sides (10,20). The first hole is aligned to the measurement on the first side (10) and the second side (20) which (101) marks the “0” starting point for measurements indicated on the first and second sides (10, 20).

The third hole (103) is in line with the third side (30) and is a centre point for an eighth side (301a) and a ninth side (301b). The third hole (103) is at the middle of the third side (30) that defines the eighth side (301a) and ninth side (301b). A protruding portion is provided to place the third hole (103) to align with the third side (30).

The fourth hole (104) is in line with the fourth side (40) of the slit. The fourth hole (104) is at the middle of the fourth side (40) to act as a centre point between the sixth side (401a) and seventh side (401b) and as a centre of rotation of the curve fifth side (50), which acts as a protractor. The fourth hole (104) marks a starting point at “0” for measurements on the fifth side (50) and the fourth side (40). The first line (201) comprises a series of holes with specific intervals.

The features of the holes as described above are not disclosed in the existing drawing instruments. The existing drawing instruments such as those disclosed D1, D2 and D3 do not teach the same features and method.

Fig. 4a an enlarged view of a portion of the first line (201) whereby the portion includes a series of holes spaced at specific intervals with 0.1 cm precision. The first line (201) facilitates users to construct circles and triangles which require a radius or a length with 0.1 precision. Scales on the first line (201) are indicated with the specific measurements. The first line (201) includes a main scale and an internal scale that correspond to holes. For example, the main scale starts at 0.0 up to 8.0 cm spaced at 0.5cm intervals, whereas the internal scale starts at 0.0 up to 0.8 cm. For example, the internal scale includes a sequence of 0.0cm, 0.2cm, 0.3cm, 0.4cm, 0.6cm and 0.8.

Referring to Fig.4a and any one of Fig.4b(i), (ii) and (iii), the first line (201) comprises a sequence of holes A, B, C, D, and E spaced at 0.2 cm from one another; followed by holes F and G spaced at 0.3 cm and 0.5cm respectively from A; and followed by a plurality of holes spaced at 0.5 cm. Fig.4b(i), (ii) and (iii) also show examples of three measurements or lengths with 0.1 cm precision. Users may use the holes between the main scale and the internal scale to obtain the said measurements. In Fig. 4b(i), the 4.1cm length is obtained when a marking tool such as a pencil is placed at a 0.6cm hole in the internal scale and a 3.5cm hole in the main scale. Fig 4b(ii) and 4b(iii) show different holes are used to obtain the measurements of 4.2cm and 4.3cm. The first line (201) provides scales that allow users to draw one or more lengths by detecting and choosing the right pair of holes. The scales are configured by locating the best perforated alignment between the main scale and the internal scale.

Figs. 5a shows an example of a question (Question 1) for drawing an image under translation that translates 7cm in the right direction and -3cm in the down direction. Figs. 5b and 5c show the steps for translating the object in the x-axis and y-axis using the drawing instrument of the present invention based on the question in Fig. 5a. The translation required for the object in Fig. 5a is 7cm in the right direction and -3 cm downward. As shown in Fig. 5b, an image of translation is drawn by placing the first side (10) at one of the vertices of the object by fixing a length of 7 cm in x-axis using the first hole (101) and marking a point at a length of 3 cm downward on the y-axis. The steps above are repeated for other vertex points in the object. The marked points are connected to draw the image, as shown in Fig. 5c.

Fig. 6a shows an example of a question (Question 2) for drawing an image under translation with 7.0cm toward the z-axis. Figs. 6b, 6c, 6d, and 6e show the steps for translating the object in the question using the drawing instrument of the present invention. As shown in 6b, the angle

of the z-axis from the origin point is determined. From the diagram, the angle of 60° from the x-axis is observed by placing the fourth hole (104) at the centre point and the fourth side (40) along the x-axis. The angle of the z-axis from the protractor (50) is then observed. In Fig. 6c, the fourth hole (104) is then placed at one of the vertices of the object and 60°.is marked. In Fig. 6d, the drawing instrument is turned until the pencil touches the fourth side (40) and the length of 7.0 cm is marked on the fourth side (40). The steps above are repeated for other vertex points in the object. Lines are drawn by connecting the marked points (i.e. using the straight edge of the instrument). Fig. 6e shows the answer after performing the above steps.

Fig. 7a shows an example of a question (Question 3) for finding a centre of rotation for 90° rotation of two images, i.e. an object and its corresponding image. Figs. 7b, 7c, 7d and 7e show the steps for finding a centre of rotation for 90° angle using the drawing instrument of the present invention based on the question in Fig. 7a. The area (AREA) of the centre of rotation as shown in Fig. 7b is estimated and the apex, i.e. the first hole (101) of the drawing instrument is placed at the area as shown in Fig. 7c. In Fig. 7c, the vertex point (Point A) and the corresponding vertex point (Point A') on the object and image are identified. The fourth hole (104) is placed on point A' in the image, and point A is aligned with the fourth side (40). The sixth hole (105b) is used and a first mark is placed. A first line (LINE A) is drawn connecting the point A' on the image and the first mark at the sixth hole (105b). As shown in Fig. 7d, the fourth hole (104) is then placed on point A in the object, and point A' is aligned with the fourth side (40). The fifth hole (105a) is used to indicate a second mark. A second line (LINE B) is drawn, connecting point A on the object and the second mark at the fifth hole (105a). The crossing of the first and second lines is the centre of rotation as shown in Fig. 7e.

Fig. 8a shows another example of question (Question 4) for finding a centre of rotation for 90° rotation of an object and its corresponding image. In Fig. 8b, a centre of rotation is obtained by identifying the vertex point and the corresponding vertex point in the object and image using the first side (10) and the second side (20), whereby the lengths from the first hole (101) to the first side (10) and the second side (20) should correspond to each other or same. When the same lengths in both the first side (10) and the second side (20) are identified, the first hole (101) is used and a mark is placed to indicate the centre of rotation for 90° rotation as shown in Fig. 8c.

Figs. 9 (i), (ii) and (iii) show a construction of a triangle with specific lengths. In this example, the width of 6.1 cm is drawn on a straight line corresponding to KL length. 5.2 cm length is

set, and a first arc is drawn from point L. 2.8 cm length is set and a second arc is drawn from point K. The second arc that crosses the first arc indicates a third vertex of the triangle.

Students usually need to equip themselves with a protractor or compass to learn geometric transformation in schools. A compass usually requires a pencil or pen to be attached to it. The present invention eliminates the use of the compass by having the first line (201). One hole on the first line (201) can be used as a pivot point, and the other holes can be used to mark or draw a circle. For example, a pin or pencil can be placed on one hole as the pivot point, and another pencil is used on any one of the holes to mark or draw a circle. The first line (201) allows users to draw figures up to 0.1cm precision.

The first line (201) may facilitate teachers in teaching interference of waves for node and anti-node lines as to differentiate crest and through in wavefronts, as shown in Fig. 10a. Semi-circular lines with multiple colours would be helpful to differentiate these two lines and may facilitate the teaching. Although using a compass is possible, attaching different colour pencils to the compass is time-consuming as the pencils need to be manually locked, unlocked, and adjusted. With the present invention, the colour pencils can be directly used on the holes provided on the first line (201) to perform the drawing shown in Fig. 10b with ease.

Fig. 11a shows an example of a question (Question 5) for drawing an image enlargement with a positive scale factor and fraction scale factor whereby the centre of enlargement is given in the question. Figs. 11b and 11c show the steps taken for the image enlargement. Enlargement of an image is drawn by placing the first side (10) at one vertex and placing the first hole (101) at the centre of enlargement. The length is identified and multiplied by the scale factor. If the scale factor is 2, the length is multiplied by 2. The calculated value of the length is marked on the first side (10) which indicates the enlargement point. The steps above are repeated for other vertex points in the object. Image is drawn based on the marked points on the first side (10). When users can enlarge the objects in 2D, users will be able to enlarge 3D images quickly with the drawing instrument of the present invention by placing a pin at the first hole (101) for a positive scale factor, as shown in Fig. 12a, 12b and 12c.

Fig. 13a shows an example of a question (Question 6) for an image enlargement with a negative scale factor whereby the centre of enlargement is given in the question. The enlargement for the negative scale factor is drawn by placing the third side (30) at one vertex of the object and placing the third hole (103) at the centre of enlargement, as shown in Fig. 13b. The length from the third hole (103) and the vertex is identified and multiplied by the scale factor. If the scale factor is -2, therefore, the users multiply by 2. The calculated value is marked at the opposite side of the third side (30) to indicate an enlargement point. The steps above are repeated for other vertex points in the object. After developing their basic skills to enlarge objects, users will be able to further enlarge 3D images by placing a pin at the third hole (103) for a negative scale factor as shown in Fig. 13d, 13e and 13f.

Fig. 14a shows an example of a question (Question 7) for constructing an image for 90° rotation whereby the centre of rotation is given in the question. Figs 14b and 14c show the steps for the image construction. An image is obtained by aligning the first hole (101) at the centre of rotation (x). The lengths of the object from one or more points of the vertices to the centre of rotation is identified and the same length is marked at the opposite side (i.e. the second side) of the first side (10). The steps are repeated for other vertices in the object.

After developing their basic skills for 90° rotation, users will be able to rotate 3D images by placing a pin at the first hole (101) as shown in Fig. 15a, 15b and 15c. The placing of the pin fixes the drawing instrument at the centre of rotation that provides flexibility to users to move around at different edges and points on the figure in clockwise or anticlockwise rotation.

Moving forward, students can enhance their skills to other shapes of objects and rotate the figures in 90° or 180°. It is possible by placing a pin at the first hole (101) and the third hole (103). Figs. 15d, 15e and 15f show an example of a 3D application under 180° rotation.

Figs. 16a and 16b show the conventional way of drawing a reflection image based on the reflection axis. Reflection of the figures with the drawing instrument can be obtained with or without a Cartesian plane. The reflected image can be constructed using the third side (30) and the second line (202) positioned on the reflection axis. When object and image are given, the reflection axis can be obtained using the third side (30) and the second line (202). After the students develop their basic skills to reflect points, they will be able to reflect 3D images over the reflection axis without the grid lines or Cartesian plane as shown in Figs. 17a, 17b and 17c.

The drawing instrument of the present invention can be used for the refraction of waves in deep and shallow water. Students usually make mistakes by drawing a line to signify the phenomena or waves in shallow regions. The students may not have adequate utensils to use for drawing the waves in shallow regions. Students also lack fundamental techniques to draw the outcome.

The correct way to draw is to have a connection of lines from one region to another. This is possible when the protractor is in connection with a set square. The present invention has made refraction of waves possible as it can draw the answer with the correct technique and a simple way to understand the fundamentals.

With the drawing instrument of the present invention, the refracted lines can be drawn much easier. First, the student identifies the different regions, whether from less dense or from more dense regions. Then, students are required to draw a perpendicular line on the wavefronts because that represents the direction of propagation of waves.

Claims

1. A drawing instrument comprising
perforations and sides to facilitate the plotting of figures for geometric transformations;
wherein the sides include a first side (10), a second side (20) and a third side (30) forming a triangle, a slit with a fourth side (40) and a fifth side (50); and the perforations include a first hole (101), a second hole (102), a third hole (103), a fourth hole (104), a fifth hole (105a) and a sixth hole (105b) characterized in that
the first, second, third and fourth holes (101,102,103,104) are in line; wherein the fourth hole (104) is a centre point between a sixth side (401a) and a seventh side (401b) and a centre point of the fifth side (50) and interlinked with the fifth and sixth holes (105a, 105b) to indicate 45° point; wherein the first hole (101) is at an intersection of the first and second sides (10,20), and the third hole (103) is in line with the third side (30) and is a centre point between an eighth side (301a) and a ninth side (301b).

2. The drawing instrument as claimed in claim 1 wherein the drawing instrument further comprises a first line (201) with a series of holes spaced at specific intervals with 0.1 cm precision.

3. The drawing instrument as claimed in claim 1 wherein the drawing instrument further comprises a second line (202) in line with the first, second, third and fourth holes (101,102,103,104).

4. The drawing instrument as claimed in claim 2 wherein the first line (201) comprises
a sequence of holes A, B, C, D, and E spaced at 0.2 cm from one another; followed by holes F and G spaced at 0.3 cm and 0.5cm respectively from A; and followed by a plurality of holes spaced at 0.5 cm.

5. The drawing instrument as claimed in claim 1 wherein the fifth side (50) is a curve with angular measurements that correspond with the fourth hole (104).

6. A method for constructing a 3D image under 180° rotation with a pin using the drawing instrument as claimed in claim 1 comprising the steps of:
aligning the third hole (103) at a centre of rotation of an object;
identifying a length of one or more vertices of the object from the centre of rotation using the eighth side (301a);
placing a pin on the third hole (103) to manipulate a rotation of the drawing instrument; and
marking the identified length at the ninth side (301b) to obtain the 3D image.

7. A method for finding a centre of rotation from two images under 90° rotation using the drawing instrument as claimed in claim 1 comprising the steps of:
placing the first hole (101) of the drawing instrument at an area;
placing the fourth hole (104) on a vertex in the first image and aligning a corresponding vertex in the second image with the fourth side (40);
placing a first mark on the fifth hole (105a) and connecting the vertex in the first image and the first mark to indicate a first line;
placing the fourth hole (104) on the corresponding vertex in the second image and aligning the vertex in the first image with the fourth side (40); and
placing a second mark on the sixth hole (105b) and connecting the vertex in the second image and the second mark to indicate a second line wherein a crossing of the first and second lines is the centre of rotation.

8. A method for finding a centre of rotation from two images under 90° rotation using the drawing instrument as claimed in claim 1 comprising the steps of:
identifying a vertex point and the corresponding vertex point in the first image and the second image using the first side (10) and the second side (20) whereby the lengths from the first hole (101) to the first side (10) and the second side (20) should correspond to each other or same; and
placing a mark on the first hole (101) to indicate the centre of rotation for 90° rotation.

9. A method for constructing circles or radius with a radius of the circle involves a 0.1 cm precision using the drawing instrument as claimed in claims 1, 2 and 4 comprising the step of marking the one or more points for the radius using the first line (201)

10. A method for drawing a 3D image under rotation of 90° with a pin using the drawing instrument as claimed in claim 1 comprising the steps of:
aligning the first hole (101) at a centre of rotation of an object;
placing the pin on the first hole (101) to manipulate a rotation of the drawing instrument;
identifying one or more lengths of the object from one or more vertices to the centre of rotation on the first side (10) or second side (20); and
marking the length on the second side (20) or the first side (10).

11. A method for drawing a triangle with one or more lengths of the triangle involves precision of 0.1 cm using the drawing instrument as claimed in claims 1, 2 and 4 comprising the step of marking one or more points for drawing radius corresponding to the length using the first line (201)

12. A method for drawing a 3D enlargement with a negative scale factor using the drawing instrument as claimed in claim 1 comprising the steps of:
aligning the third side (30) at one vertex and placing the third hole (103) at a centre of enlargement of an object;
identifying one or more lengths of the object from one or more vertices to the centre of enlargement;
multiplying the lengths by the negative scale factor to obtain a value;
marking the value on the eighth side (301a) or ninth side (301b) to indicate points for the enlargement;
placing a pin on the third hole (103) to manipulate a rotation of the drawing instrument while marking the points.

13. A method for drawing a 3D enlargement of an object with a positive scale factor using the drawing instrument as claimed in claim 1 comprising steps of:
aligning the first side (10) at one vertex of the object and placing the first hole (101) at a centre of enlargement of the object;

identifying one or more lengths of the object from one or more vertices to the centre of enlargement;

multiplying the length by the positive scale factor to obtain a value;

marking the value on the first side (10) or second side (20) to indicate one or more points for the enlargement; and

placing a pin on the first hole (101) to manipulate a rotation of the drawing instrument while marking the points.