Innovative & Effective Low-tech Low-cost Teaching Methodologies for Engineering Graphics Course to Retain First Year Engineering Students

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Withdraw Or Change Majors


- ~40-50% of engineering students withdraw or change majors within their first year

- Three key reasons:
  1. poor teaching and advising;
  2. difficulty of the engineering curriculum; and a
  3. lack of “belonging” within engineering.

- Each, in some way,
  - erodes a student’s self-efficacy, or
  - confidence in his or her ability to perform.
Issues With 1st Year Engineering Student

- Studies shows…
  - 1st year engineering courses are demanding in (alone or together):
    1. **mathematical abilities**
       - Quantifying things, making hypothesis and proving them
    2. **spatial abilities**
       - Visualizing the world in three-dimensional (3D) domain
  - Particularly, for an engineering graphics course heavily desires the three-dimensional spatial visualization (3DSV) skills to be successful.
What is Spatial Visualization Ability?

- Ability to see and think in 3-D.
- Students with developed spatial visualization skills are more successful in engineering, chemistry and calculus courses.
Let have a quiz………. 
You are to 
1. Study how the object in the top line of the question in rotated 
2. Picture in your mind what the object shown in the middle line of the question look like when rotated in exactly the same manner 
3. Select from among five drawings (A,B,C,D, or E) given in the bottom like of the question the one that looks like the object rotated in the correct position 

What is the correct answer to the example shown above ?

Based on Purdue Spatial Visualization Tests – Guay, 1976
What is Spatial Visualization?

- Let have a quiz........
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  3. Select from among five drawings (A,B,C,D, or E) given in the bottom like of the question the one that looks like the object rotated in the correct position
- What is the correct answer to the example shown above?
- Correct Answer is “D”

Based on Purdue Spatial Visualization Tests – Guay, 1976
How Do You Feel About This Spatial Problem?

1. I enjoyed solving the spatial problem and want more

2. I thought the problem was easy but I don’t need more

3. I have always hated spatial tests. Please stop

4. Solving it made my palms sweat and gave me a headache

Reference: Recorded webinar: Improving Spatial Visualization Skills from ENGAGE in Engineering project - Research-based Strategies from Dr. Sheryl Soccy to Retain Undergraduates in Engineering.
How Do You Feel About This Spatial Problem?

Result of Survey:

1. I enjoyed solving the spatial problem and want more
   - 56%

2. I thought the problem was easy but I don’t need more
   - 29%

3. I have always hated spatial tests. Please stop
   - 10%

4. Solving it made my palms sweat and gave me a headache
   - 5%

Reference: Recorded webinar: Improving Spatial Visualization Skills from ENGAGE in Engineering project—Research-based Strategies from Dr. Sheryl Scoy to Retain Undergraduates in Engineering.
How Do You Think About This Spatial Problem?

I think…..

1. All college students have well-developed spatial skills
2. Spatial skills are not that important to engineering success
3. Women and men perform about the same on spatial tests
4. Spatial skills are innate and cannot be learned

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What Do You Think About This Spatial Problem?

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All of the above statements were **FALSE** !!

The truth is…

1. Not all of the students have well-developed spatial skills
2. Spatial skills are important to success in engineering
3. The spatial skills of women typically lag behind those of the men
   - Hold true for student from lower Socioeconomic status (SES) groups, too
4. Spatial Skills can be learned..
What is the Matter?

- **Concerns**
  - 80% of the students who performed badly in their first year engineering graphics course either change the major or not pursue engineering.
  - Desired 3D spatial visualization skills - success in engineering graphics course
  - Inability to cultivate 3DSV skills - crushed their self-confidence and causes a poor performance.
  - While spatial skills are important for engineering success, they are not typically taught in high school, so you may not have had this type of instruction or practice.

- **Probable Solution**
  - Students with developed spatial visualization skills are more successful in engineering, chemistry and calculus courses.
  - These skills can be developed over time with specific training and practice.
  - So it can be taught and learn how to ‘see’ things in 3-D, improving success in these subjects and in ability to problem solve.

- Various researchers showed various methods to improve 3DSV skills, however, these methodologies are mostly high-tech, expensive, and inaccessible.
Our Solution

To enhance students’ spatial visualization skills and retain enrollment
• For the first-year engineering students in engineering graphics class

An innovative and effective low-tech low-cost teaching methodologies
Our Plan

To enhance students’ spatial visualization skills and retain enrollment

- For the first year engineering students in engineering graphics class

**Week 1-8: Fundamental of Engineering Graphics**
- 2D Free hand drawings – 3D Isometric Blocks
- Multiview drawings (3D to 2D) – Front, Side, Top views of 3D blocks
- Section view - 3D Isometric Blocks
- Assembly drawings – many 3D blocks

**Week 8: Evaluation of Fundamentals – Exams/Quiz**

- The course curriculum was developed in such a way that class notes and instructions go along with these modeling tools

**Week 9-16: Introduction of Modeling tools -** To make 3D models/objects to aid in visualization
- Repeat Multiview drawings (3D to 2D), Section view, and Assembly drawings
  - Modeling Clay and Magnetic Pads
  - Pepakura Designs - Makes unfolded patterns of 3D model
  - 3D Printed Models
  - Animated Videos using SolidWorks

**Week 16: Evaluation of Fundamentals – Exams/Quiz and Draw conclusion**

- Two 50 min theory session and one two-hour lab session per week (spilt into two section of 23 students)
- Short mini lecture before lab session
- Group of 4 students work together in a group and solve the lab assignments
Fundamental Of Engineering Graphics

Spatial Visualization Process to draw Multiview drawings

One method of interpreting sketches is to reverse the mental process used in projecting them

Section Views

Half section
Tool 1 - Modeling clay

- **Modeling Clay**
  
  - 3D models are made using playdoh.
  - Physically get the feel of the object in the 3D space domain.
  - Liberty to perform transformation operations such as Rotation.
  - **Merits:**
    - Only cost - 20 containers for $13.99.
    - Can be used again and again.

Try making a clay model from 2D projected views:
Tool 2 – Magnetic Pads

- Magnetic Pads - Playmags

- 3D models were made using playmags
- Physically get the feel of the object in 3D space domain
- Liberty to perform transformation operations such as Rotation
- Merits:
  - 120 piece set costs $69.99
  - Can be used again and again.
Tool 3 – Pepakura Design

- Makes 2D unfolded patterns of 3D model
- 3D models where made using 2D unfolded patterns
- Physically get the feel of the object in 3D space domain
- Liberty to perform transformation operations such as Rotation
- Merits:
  - It’s Free open source software – Full version Pepakura Designer 4 is $38 USD
  - Easy to print. Generally send out to student along with drawing assignment.

Examples
https://www.tamasoft.co.jp/pepakura-en/
Tool 4 — 3D Printed Models

- 3D Printer – Rapid prototyping of 3D object

Examples:

3D Models – more complicated blocks

- 3D models made using 3D printers
- Physically get the feel of the object in 3D space domain
- Liberty to perform transformation operations such as Rotation

Merits:
- Easy to print. Can be made for any complicated design.
- Student can also learn how to make parts using SolidWorks and physically print 3D parts using 3D printers
Tool 5 — Animated Videos using SolidWorks

- **Virtual Simulation of 3D object – Fold/unfold**

![3D Model Examples](image)

3D Models – more complicated blocks

- Animation of folding/unfolding of 3D object can be done using SolidWorks
- Virtually get the feel of the object in 3D space domain

**Merits:**
- Easy to share the animation files. Can be made for any complicated design.
- Student can learn how the parts are assembled together
- No to bare minimum cost

**Examples**
Week 16: Evaluation of Fundamentals – Exams/Quiz

After introducing the various modeling tools to aid spatial visualization

Question types:

1. Rotated Views
2. Wrong Views
3. Missing Views/ find correct views
4. Multiview to isometric
5. Sectional Views
Type 1: Rotated Views

Based On Purdue Spatial Visualization Tests

- Visualization of Rotations

- You are to

  1. Study how the object in the top line of the question in rotated
  2. Picture in your mind what the object shown in the middle line of the question look like when rotated in exactly the same manner
  3. Select from among five drawings (A, B, C, D, or E) given in the bottom like of the question the one that looks like the object rotated in the correct position

- What is the correct answer to the example shown above?

Based on Purdue Spatial Visualization Tests – Guay, 1976
We need to draw another block

This type of question have purposely kept the views in wrong position and student needs to find the error or choose the correct views.

Each of the blocks shown in isometric projection below (on the left) corresponds to one of the multiview drawings on the right in the same row. Match each multiview with its correct pictorial and darken the corresponding number on your answer sheet.

Answer: 20 $\rightarrow$ 1, 21 $\rightarrow$ 2, 22 $\rightarrow$ 3

Each of the blocks shown in isometric projection below correspond to one of the multiview drawings in the second row. Match each multiview with its correct pictorial. Completely darken the multiview’s drawing corresponding number on your answer sheet.

Answer: 19 $\rightarrow$ 2, 20 $\rightarrow$ 4, 21 $\rightarrow$ 1, 22 $\rightarrow$ 3
Type 3: Missing Views/ Find Correct View

For questions 21 through 23: Two views of each of the problems shown below are correct. One of the four drawings of the third view is also correct, however three of them are incorrect. Select the correct view and record the number on the answer sheet. Answer: 21 → 1, 22 → 2, 23 → 1

For questions 23 through 25: Two views of each of the problems shown below are correct. One of the four drawings of the third view is also correct, however three of them are incorrect. Select the correct view and record the number on the answer sheet. Answer: 23 → 2, 24 → 2, 25 → 4
For questions 23 through 25: Two views of each of the problems shown below are correct. One of the four drawings of the third view is also correct, however three of them are incorrect. Select the correct view and record the number on the answer sheet.

Answer: 23 → 2, 24 → 1, 25 → 4

For questions 23 through 25: Two views of each of the problems shown below are correct. One of the four drawings of the third view is also correct, however three of them are incorrect. Select the correct view and record the number on the answer sheet. Answer: 23 → 2, 24 → 1, 25 → 4
Type 4: Multiviews To Isometric

For questions 27 through 30: Each of the blocks shown in multiview projection below (on the left) corresponds to one of the isometric drawings on the right. Match each multiview with its correct pictorial and darken the corresponding number on your answer sheet. Answer: 27 \(\rightarrow\) 2, 28 \(\rightarrow\) 4, 29 \(\rightarrow\) 3, 30 \(\rightarrow\) 1

27. The front view of a block is shown below. There are four blocks shown and one of them is incorrect. Select the incorrect block.

28. Two views (front and top) of a block are shown below. There are four blocks shown on the right side and one of them is incorrect. Select the incorrect block.

29. Two views (front and top) of a block are shown below. There are four blocks shown on the right side and one of them is incorrect. Select the incorrect block.
Type 5: Sectional Views

For questions from 28 to 30, the top and front view of an object are given for each problem. Select the full section created when the cutting plane passes through the top view as shown.

28. (4)

30. (3)

1. Which figure below is an example of a correct section view? (2)
Conclusion

- The methodology was utilized for Spring semester for 56 students

- **Midterm grades: Average: 58.93 %**

- **End of term grades: Average: 81.59 %**

- Preliminary results and surveys show that the students drastically improved their 3DSV skills with these implemented methodologies.

- **Modeling clay is the most popular among the all other modeling methods.**

- The current research currently seeking approval for OSU-Stillwater: Human Subject Research for more conducting systematic research and drawing conclusions.
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Thank You

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ANY QUESTIONS?
GREETINGS FROM OSU

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