**Thinking like an Engineer Project (2015/16)**

**ENGINEERING HABITS OF MIND TOOLKIT**

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In our initial report ‘*Thinking like an engineer: implications for the education system’,* we identified six habits of mind thatengineers use most frequently when engaged in the core activity of ‘making’ things or ‘making things work better’. These six engineering habits of mind (EHoM), in the middle circle of the diagram, are:

**Systems thinking**: - seeing whole systems and parts and how they connect, pattern-sniffing, recognising interdependencies, synthesising

**Adapting**: - testing, analysing, reflecting, rethinking, changing both in a physical sense and mentally

**Problem-finding**: - clarifying needs, checking existing solutions, investigating contexts, verifying

**Creative problem-solving**: - applying techniques from different traditions, generating ideas and solutions with others, generous but rigorous critiquing, seeing engineering as a ‘team sport’

**Visualising**: - being able to move from abstract to concrete, manipulating materials, mental rehearsal of

practical design solutions

**Improving**: - relentlessly trying to make things better by experimenting, designing, sketching, guessing, conjecturing, thought-experimenting, prototyping.

We are now asking teachers to develop lesson plans in which outcomes that might contribute to developing the six EHoM are delivered. This handout offers some tools which might help you evaluate these lessons and contribute to our understanding of how EHoM can be developed and sustained in learners through everyday teaching interactions.

**EHoM Toolkit**

In order to help you develop lesson plans in which outcomes might contribute to developing the six full EHoM, we have identified two contributory habits of mind for each EHoM, which makes for 12 habits of mind in all.

These descriptions of the habits of mind of engineers can be used to develop a variety of tools and prompts in your teaching:

1. a self-report questionnaire suitable for KS2/3
2. an observation schedule for use by teachers
3. a basis for identifying linguistic prompts and nudges used by teachers and STEMNET ambassadors
4. a basis for identifying focused interventions designed to develop each habit of mind.

The six Engineering Habits of Mind (EHoM) and 12 sub-habits are listed below, each with a headline description of what it might look like:

**SYSTEMS-THINKING**

1. **Connecting:** looks forlinks and relationships; likes to work across boundaries
2. **Pattern-making**: uses connections to make new meaning – metaphors, formulae, images, products

**PROBLEM-FINDING**

1. **Checking and clarifying**: questions apparent solutions methodically and reflectively
2. **Investigating**: has a questioning, curious and, where appropriate, sceptical attitude

**VISUALISATION**

1. **Thinking out loud**: puts 3D ideas into words as they picture or rehearse possible lines of thought or action
2. **Model-making**: moves between abstract and concrete, making models to capture ideas

**IMPROVING**

1. **Experimenting**: keen to make small tests or change; sketching, drafting, guessing, prototyping
2. **Evaluative**: makes honest and accurate judgments about ‘how it’s going’; comfortable with words and numbers as descriptors of progress

**CREATIVE PROBLEM-SOLVING**

1. **Generating ideas**: comes with suggestions in a range of situations
2. **Working in team**: has good people skills to enable idea and activity sharing; goo at giving and receiving critique/feedback

**ADAPTING**

1. **Critical thinking:** analyses ideas, activities and products; able to defends their own thoughts and ideas in discussion and also to change their mind in light of evidence
2. **Deliberate practising:** disciplined; able to work at the hard parts.

**You can use this survey before, during and after your intervention, to gather student views on their EHoM skills level, but don’t forget that students may judge themselves more harshly after they have become more competent, so in your second/third iteration of the survey, add in a phrase such as that suggested in red below, amended to suit your own context.**

**EHoM QUESTIONNAIRE FOR LEARNERS**

This is a quiz to find out how you see yourself when you are trying to do things that are new or difficult. There are 12 statements. Look at each one and think how true this is of you when you are learning (now, compared to how you felt before we started the EHoM activity). This includes things you are learning for your own interest out of school, as well as in lessons. Of course we all vary, but try to choose the answer that is closest to you in general. If you think a statement is rarely or never true of you, circle the 1. If you think it is sometimes true, circle 2. If you are quite often like that, circle 3. And if the statement is true very often or always, circle 4.

Remember:

|  |  |  |  |
| --- | --- | --- | --- |
| 1 = rarely (or never) | 2 = sometimes | 3 = quite often | 4 = very often (or always) |
| http://www.measuringu.com/images/faces_scales.jpg | http://www.measuringu.com/images/faces_scales.jpg | http://www.measuringu.com/images/faces_scales.jpg | http://www.measuringu.com/images/faces_scales.jpg |

Date………………………………………………..

Name………………………………………………. Class………………………………………..

1. I like making links between things in my head 1 2 3 4
2. I enjoy putting things together to make something new 1 2 3 4
3. I’ll check and check again until I am happy 1 2 3 4
4. I love asking questions and having my own point of view 1 2 3 4
5. I like thinking out loud when I am being imaginative 1 2 3 4
6. I like making models to show my ideas 1 2 3 4
7. I like making what I’ve done better 1 2 3 4
8. I explain how well I am doing to my teacher or friends 1 2 3 4
9. My brain comes up with lots of good and new ideas 1 2 3 4
10. I like working in a group 1 2 3 4
11. I stick up for what I think when talking with other people 1 2 3 4
12. I work hard and practise to get better, even when it’s tricky 1 2 3 4

**EHoM OBSERVATION SCHEDULE FOR TEACHERS AND RESEARCHERS**

Teacher’s name / initials………………………………….

Student name…………………………………………………..

Class…………………………………………………………………

Date………………………………………………………………….

For each student, please give a rating, 1 – 4, on each of the 1 EHoM listed below. Especially think about the student when they are facing something new or challenging.

1 = they are *rarely or never* like this 2 = they are *sometimes* like this

3 = they are *quite often* like this 4 = they are *very often or always* like this

**1. Connecting:** tends to look forlinks and relationships; likes to work across boundaries

 1 2 3 4

**2. Pattern-making**: enjoys combining things using metaphors, formulae, images,

products to demonstrate this 1 2 3 4

**3. Checking and clarifying**: questions apparent solutions methodically and reflectively 1 2 3 4

**4. Investigating**: has a questioning, curious and, where appropriate, sceptical attitude 1 2 3 4

**5. Thinking out loud**: puts 3D ideas into words as they picture or rehearse possible

lines of thought or action 1 2 3 4

**6. Model-making**: moves between abstract and concrete, making models to

capture ideas 1 2 3 4

**7. Experimenting**: keen to make small tests or change; sketching, drafting, guessing,

prototyping 1 2 3 4

**8. Evaluative**: makes honest and accurate judgments about ‘how it’s

going’; comfortable with words and numbers as descriptors of progress1 2 3 4

**9. Generating ideas:** comes with suggestions in a range of situations 1 2 3 4

**10. Working in team**: has good people skills to enable idea and activity

sharing; goo at giving and receiving critique/feedback1 2 3 4

**11. Critical thinking:** analyses ideas, activities and products; able to defends their own

thoughts and ideas in discussion and also to change their mind in light of evidence 1 2 3 4

**12. Deliberate practising:** disciplined; able to work at the hard parts. 1 2 3 4

**EHoM - TEACHER PROMPTS**

Below are some illustrations of ways of prompting and ‘nudging’ students towards using and developing the 12 habits of mind during classroom and extra-curricular activities to be used as you help students with their work. **Please help us add to this list by noting down any prompts that you tried with your learners.**

**SYSTEMS-THINKING**

**1. Connecting:** What does that remind you of?’, ‘What do these things have in common?’ ‘What would this be like if we tried it somewhere else?**’**

**2. Pattern-making**:

**PROBLEM-FINDING**

**3. Checking and clarifying**:

**4. Investigating**:

**VISUALISATION**

**5. Thinking out loud**:

**6. Model-making**:

**IMPROVING**

**7. Experimenting**:

**8. Evaluative**:

**CREATIVE PROBLEM-SOLVING**

**9. Generating ideas:**

**10. Working in team**:

**ADAPTING**

**11. Critical thinking:**

**12. Deliberate practising:** ‘What do you need to practise that a bit more?’, ‘What would you need to do to improve that?’, ‘What could you tinker with?’